

Respiratory Anatomy

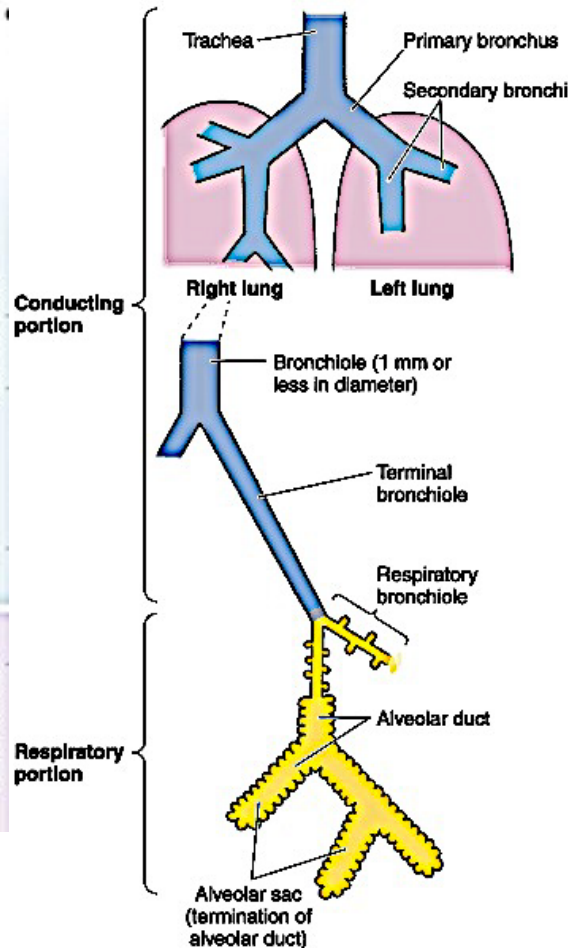
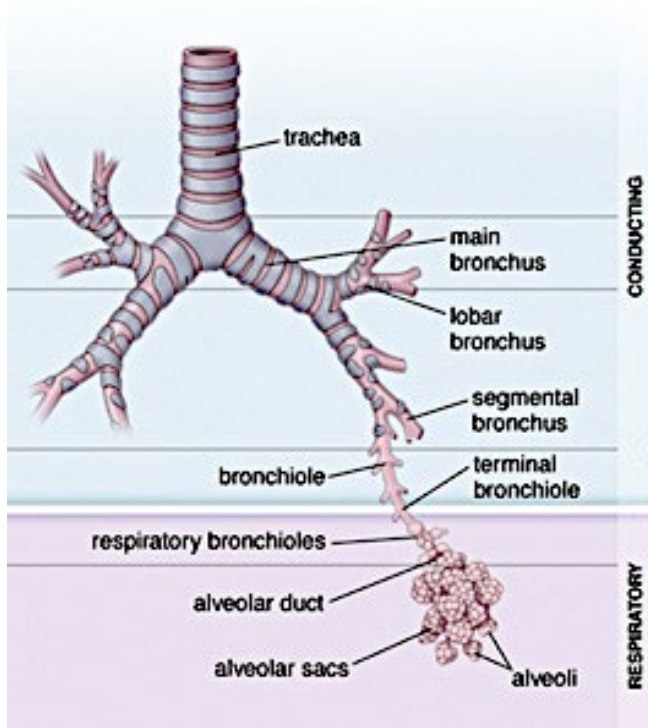
Olutayo Ariyo MBBS., MBA
SKMC @ Thomas Jefferson University.
2017

Outlining:

- The major anatomical and functional regions of the respiratory system
- Emphasis on changing microanatomy as related to function
- Brief introduction to Respiratory Diseases and Etiology

Respiratory System

Provides for exchange of O_2 and CO_2 to and from the blood.



2 functional components

Air-conducting (Blue)

(From nasal cavities to Terminal bronchiole)

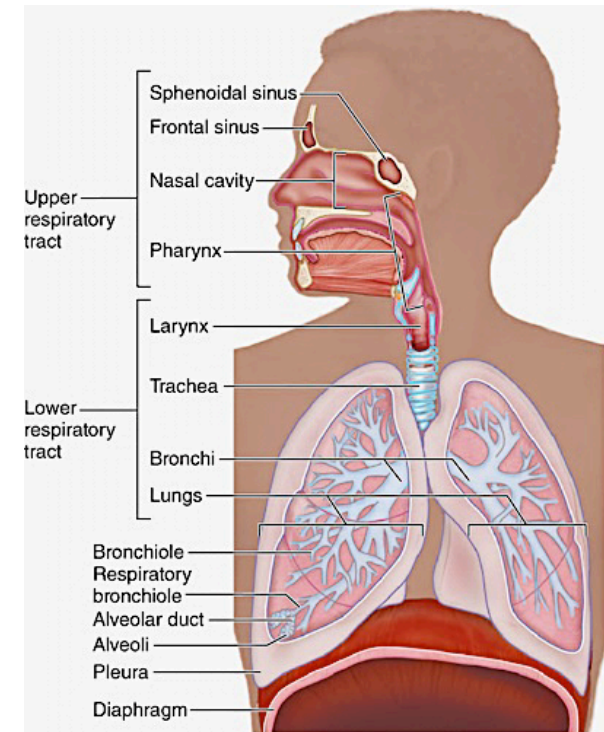
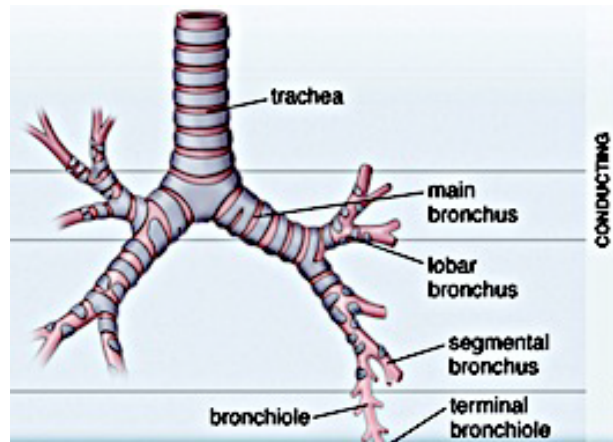
Respiratory portion - Yellow

(From respiratory bronchiole to alveoli)

Composition of the Conduction and Respiratory Portions

Conducting portion (Air conduction and conditioning)

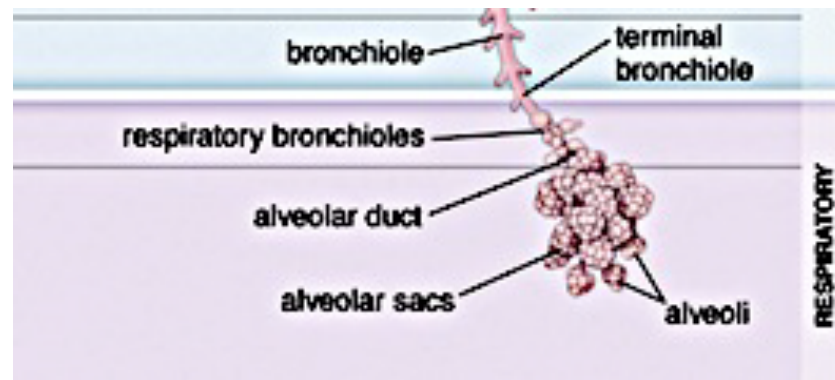
- Nasal cavities
- Pharynx
- Larynx
- Trachea
- Bronchi
- Bronchiole
- Terminal bronchiole



Source: Anthony L. Mescher: Junqueira's Basic Histology, 14th Edition.
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Respiratory portion (For gaseous exchange)

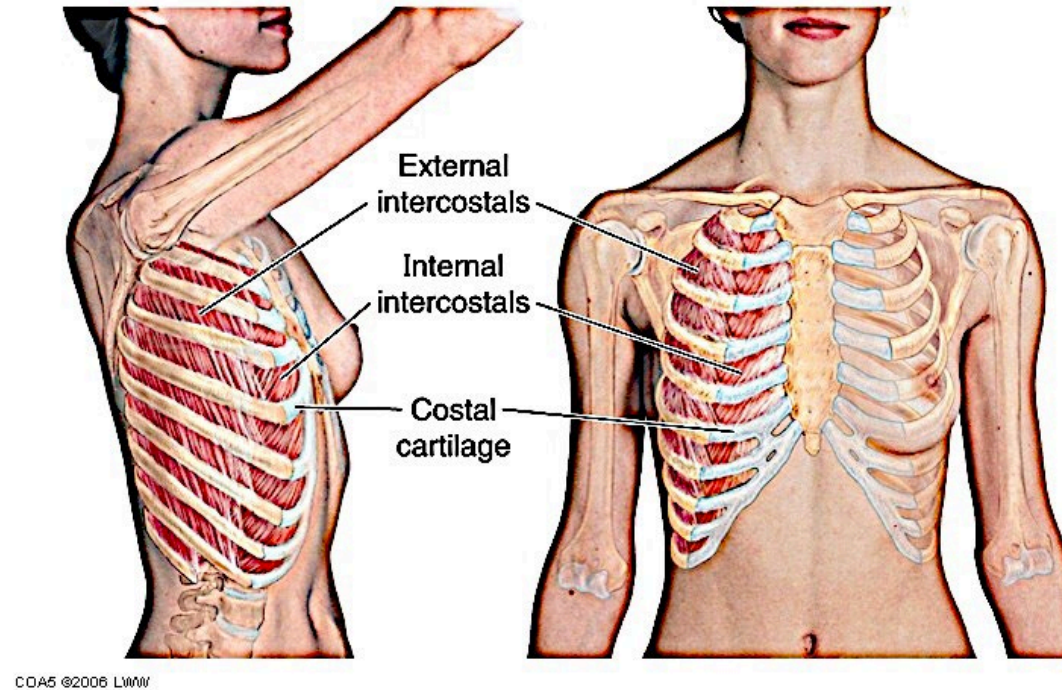
- Respiratory bronchioles
- Alveolar ducts
- Alveoli



Ventilating Mechanism (VM)

VM- Moves air through the lungs (Inflow (**Inspiration**) - Outflow (**Expiration**))

- Thoracic cage
- Intercostal muscles
- Diaphragm
- Elastic connective tissue of lung tissue



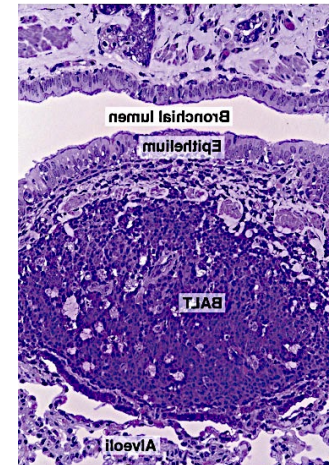
Pulmonary Defense System

Natural

1. Physical integrity of covering epithelium
2. Secretions
3. Ciliated cells

Acquired

4. Lymphocytes and inflammatory cells aggregates



BALT (Bronchus Associated Lymphatic Tissue)

MALT (Mucosa Associated Lymphatic Tissue) As Waldeyer's ring in Nasopharynx

- Secondary lymphoid structures, where most **lymphocytes are activated by antigen presentation**

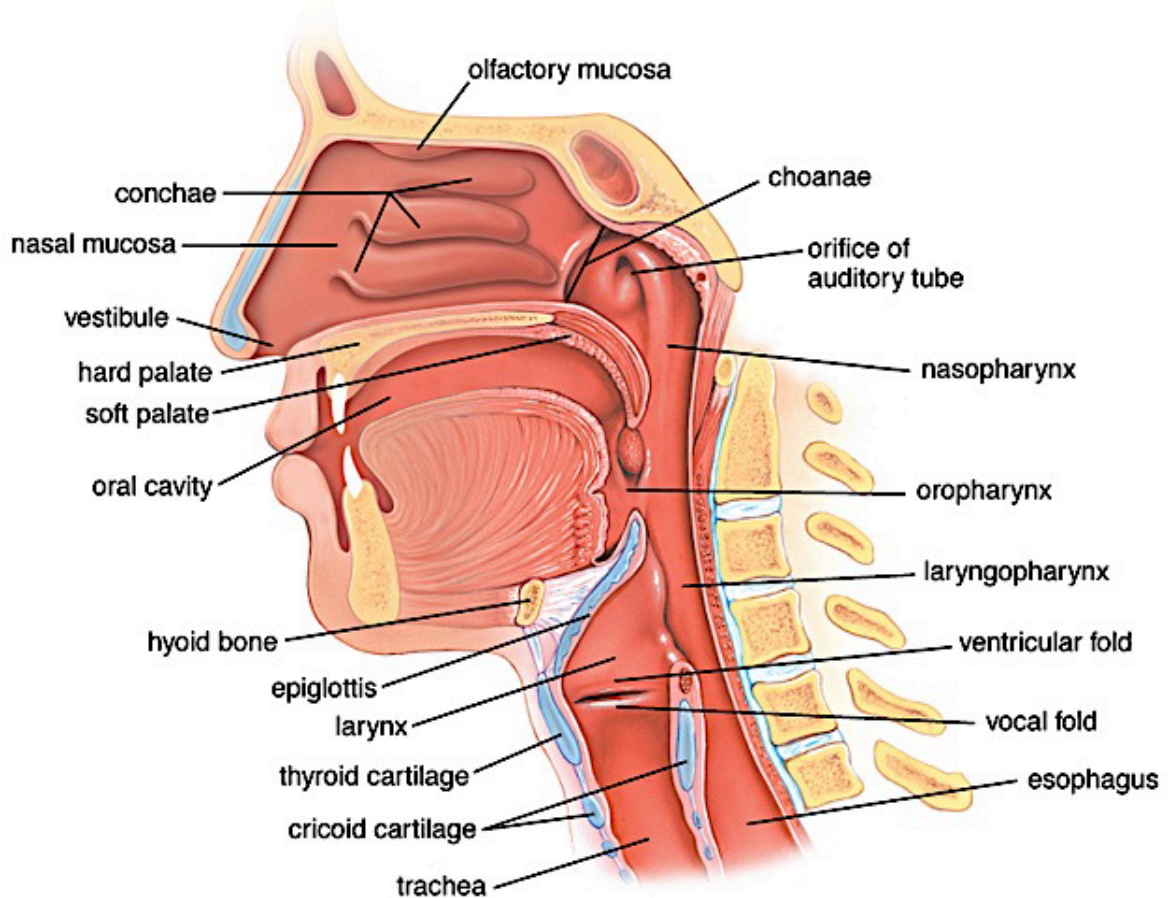
Nasal cavity and Nasal Septum

- Humidification
- Conduits for air movement
- Filtration of dust particles
- Moisturizing

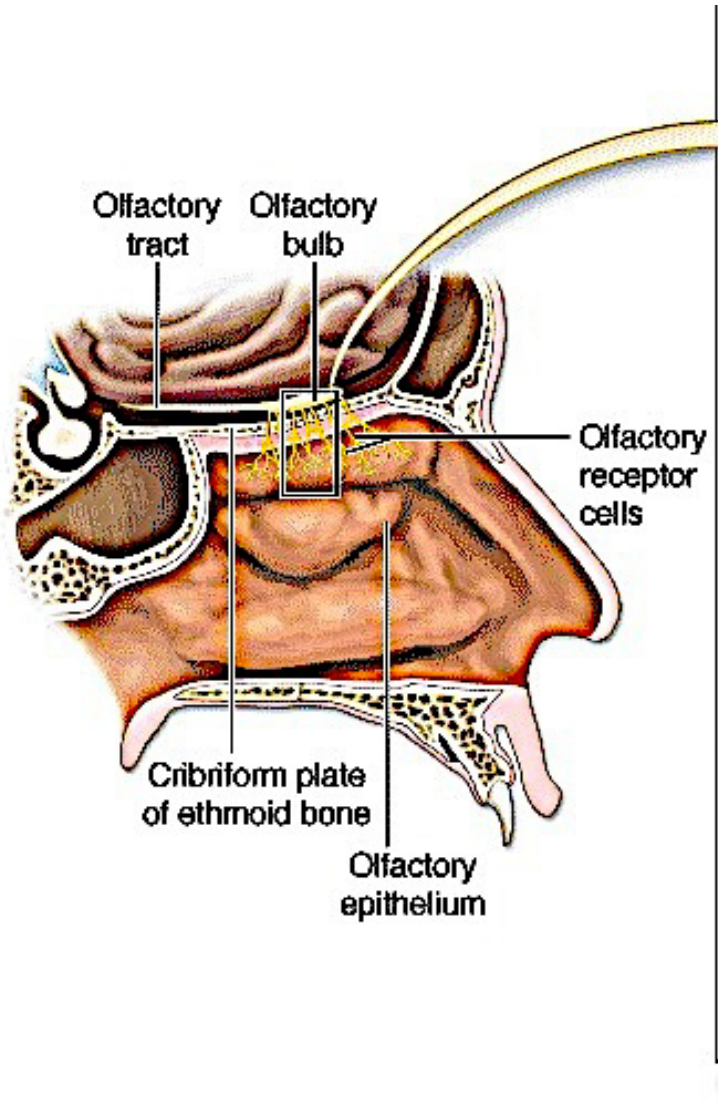
Secretions from seromucous and goblet cell

-traps particulate and gaseous air impurities

- **Concha and air turbulence *****



Regions of the Nasal Septum



Vestibule

Respiratory

Olfactory

3 Regions of the Septum and their Epithelial Lining

1. Vestibule

External lining

- General body skin (Stratified squamous keratinized)

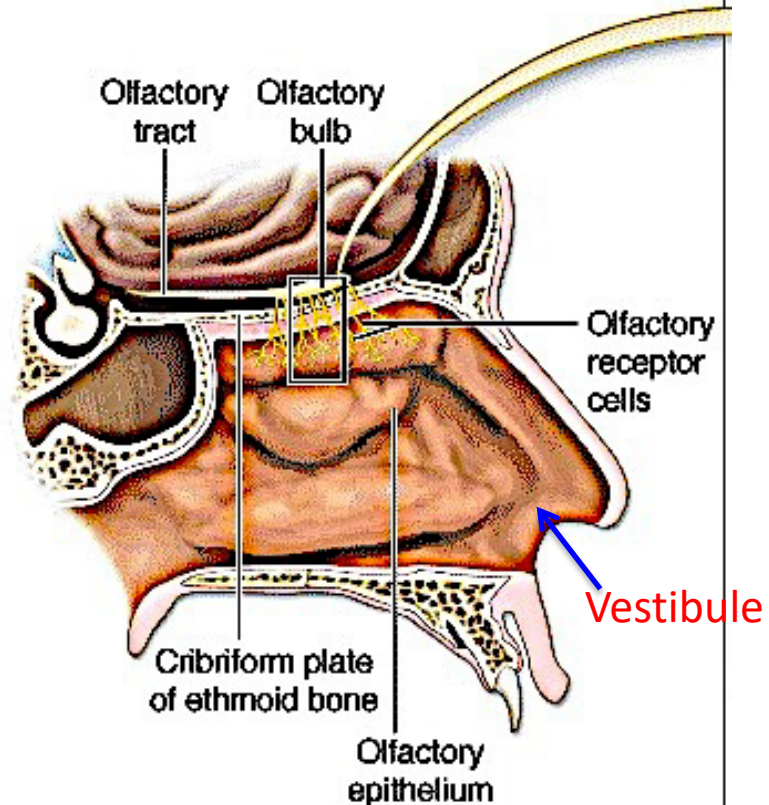
Internal lining

- Non keratinized squamous

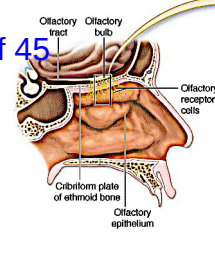
2. Respiratory

- PCCE
- Rich superficial venous plexus
- Lamina propria
- Connective tissue
- Seromucous glands

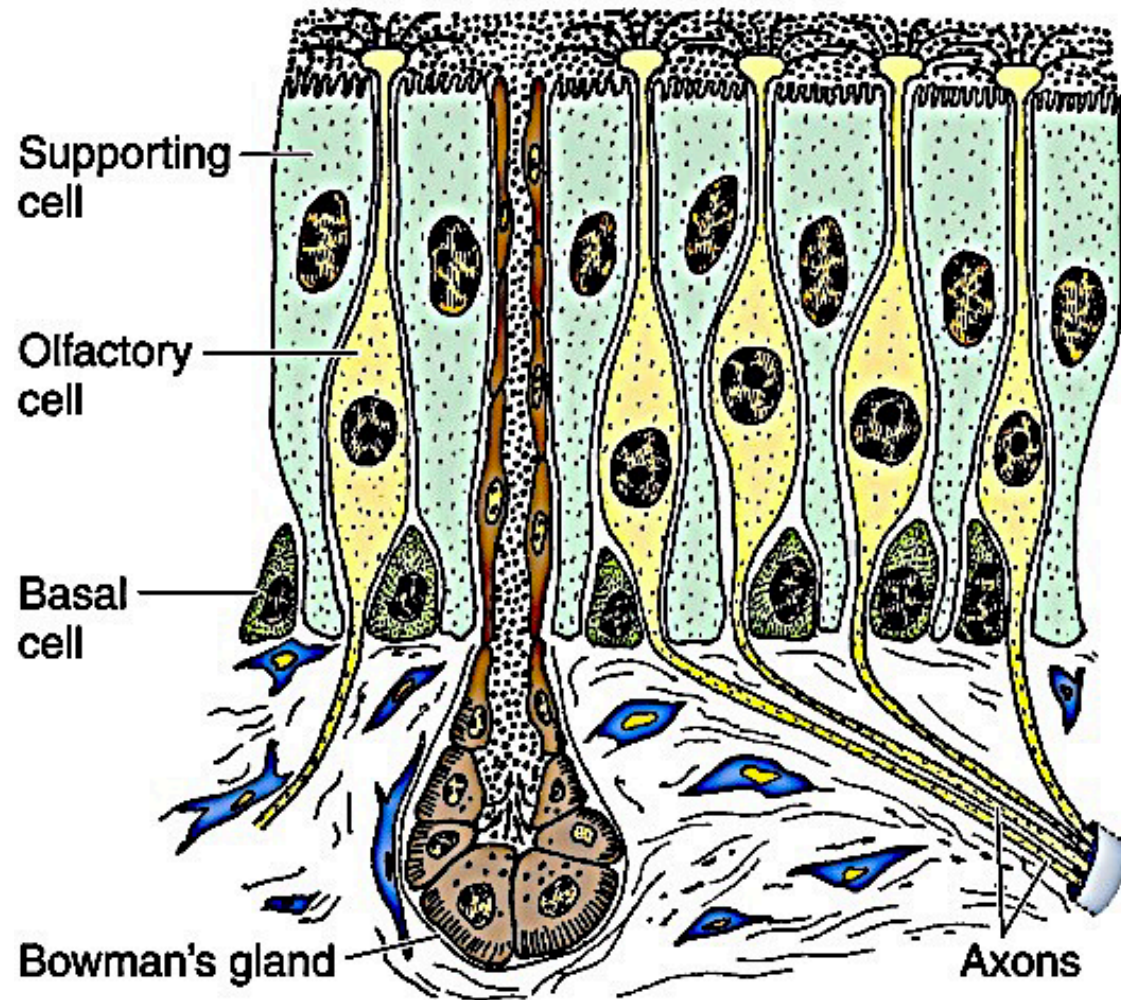
3. Olfactory area



Olfactory Epithelium



Source: Mescher AL, Junqueira's Basic Histology: Text and Atlas, 12th Edition. <http://www.accessmedicine.com>



4 major cell types

1. Basal

2. Immature (differentiating)

3. Mature olfactory neurons
(polarized)

4. Supporting
(Sustentacular cells)

Bowman gland secretions

- Odorous-binding Protein (OBP)
- Lysozyme and IgA

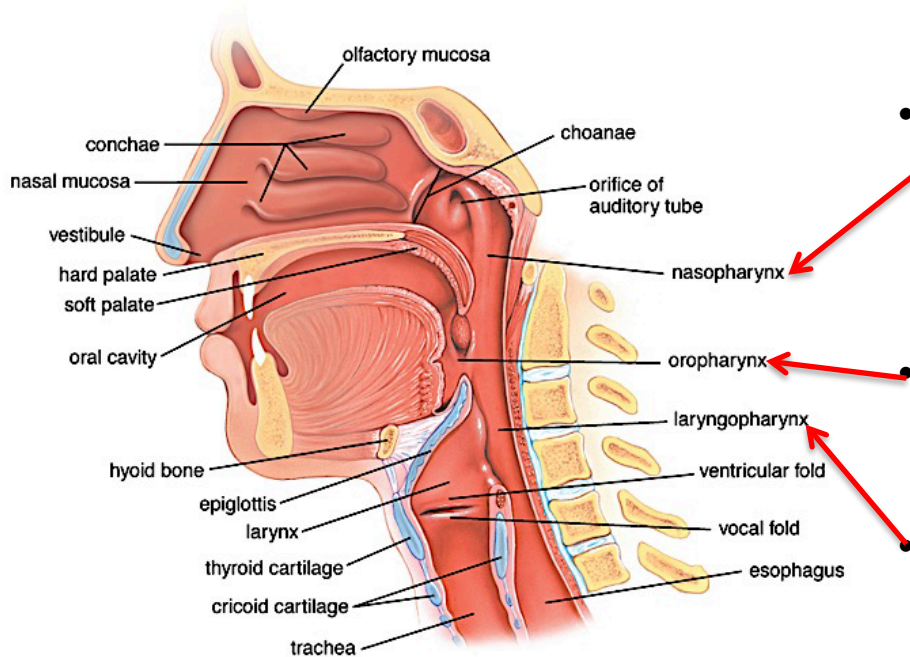
A specialized region of the mucous membrane covering the superior conchae at the roof of the nasal cavity.

Paranasal sinuses

- Frontal
 - Maxillary
 - Ethmoid
 - Sphenoid
-
- Lined by thinner respiratory epithelium
 - Fewer glands
-
- Communicate with the nasal cavities through small openings;
 - Mucus produced moved into the nasal passages by the activity of the ciliated epithelial cells.

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Epithelial Coverings Of Paranasal Sinuses, Nasopharynx



- Nasopharynx - PCCE

Oropharynx - Non keratinizing squamous

Laryngopharynx

PCCE except over true vocal cord region
of the larynx

Laryngeal Epithelium and Reinke's Space

Pseudostratified columnar ciliated
except

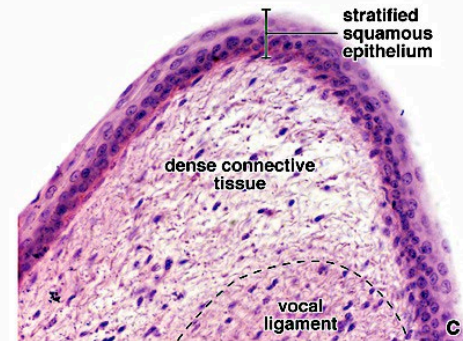
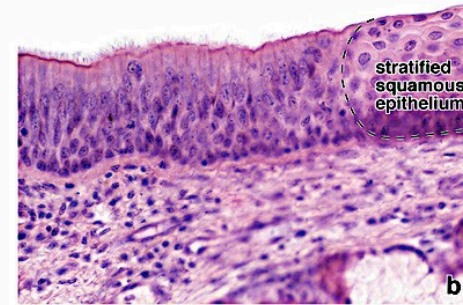
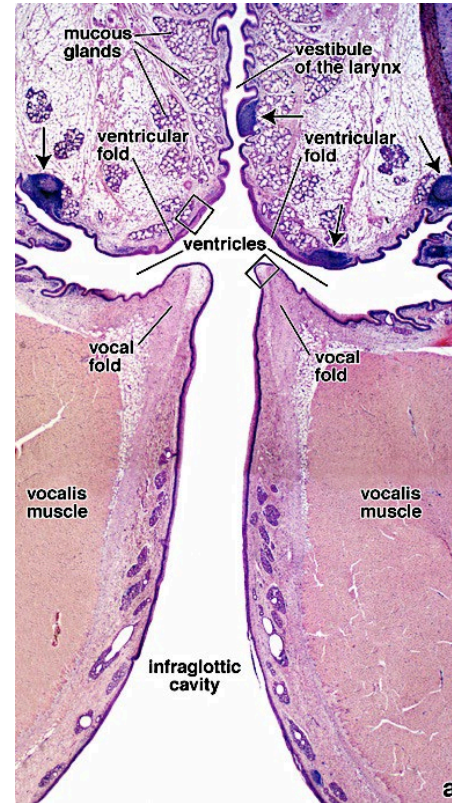
Region of true vocal cord (VC)

- No seromucous glands

Epithelium of true vocal cord

- **Stratified squamous**
- Reinke's space in lamina propria
- Rich in mast cells

G-Glands-in laryngeal vestibule (LV)

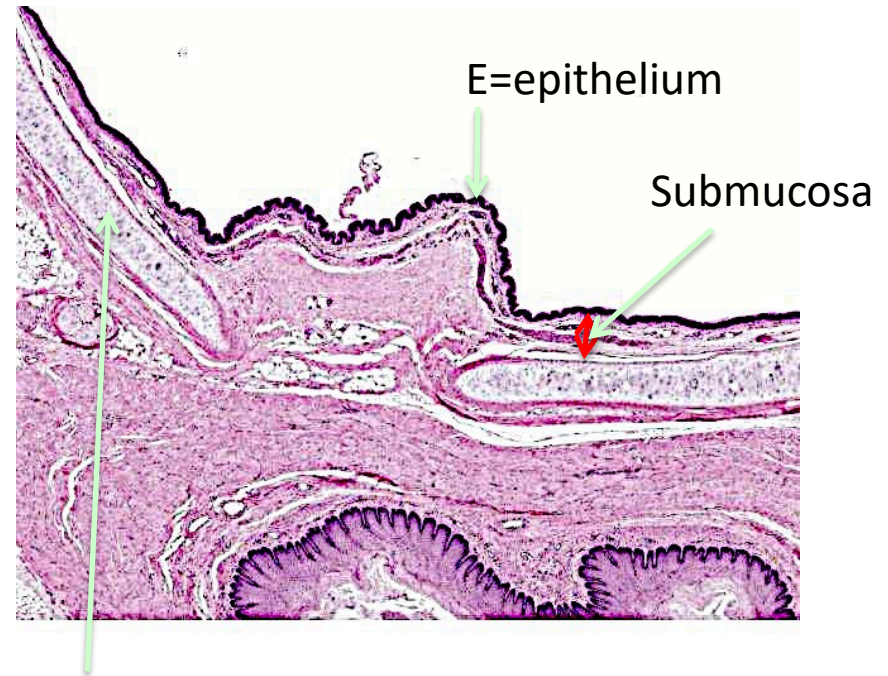


- LV-Laryngeal vestibule surrounded by seromucous glands.
- VF-Vestibular fold contains seromucous gland. MALT
- VC- Vocal cord, covered by STRATIFIED squamous epithelium

L-Lymphoid nodules

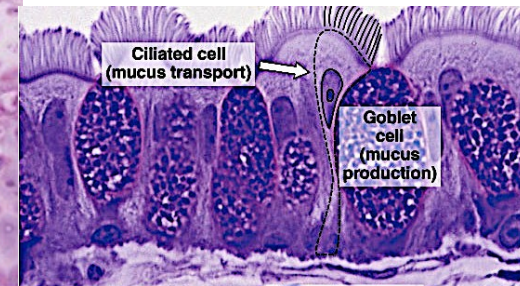
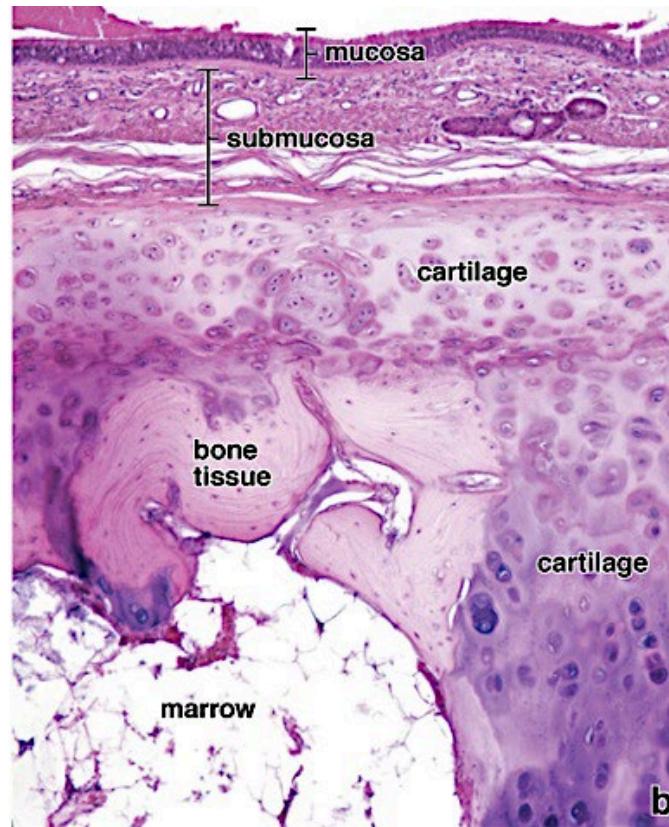
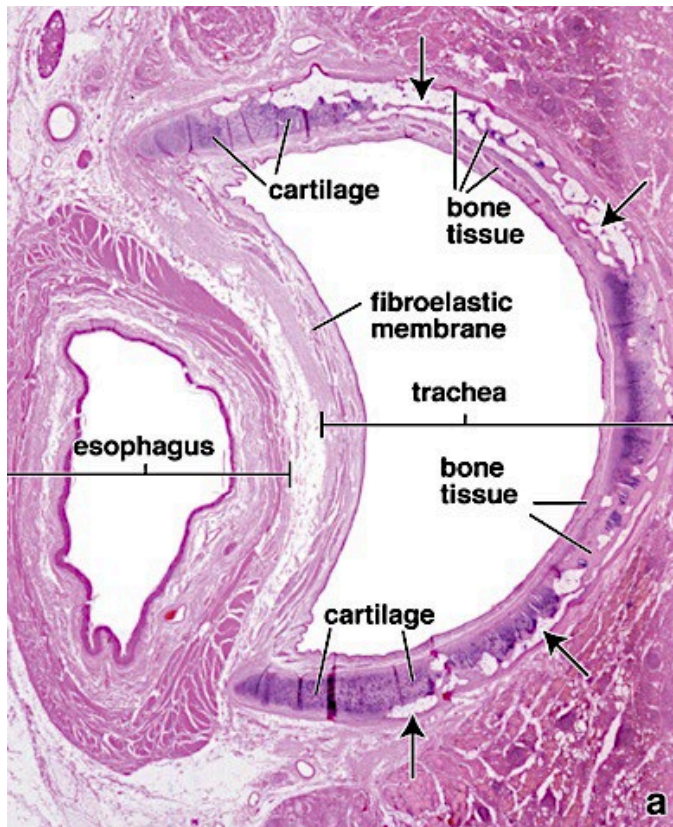
Trachea

- Hollow organ with 3 basic layers
 - Mucosa
 - Submucosa
 - Adventitia
- No distinct muscularis mucosae



Hyaline cartilage + fibroelastic
layer = Adventitia

MA of the Trachea



- About a dozen C-shaped rings of hyaline cartilage
- Open ends point posteriorly bridged by Trachealis muscle

Respiratory epithelium

Has 5 major cell types;

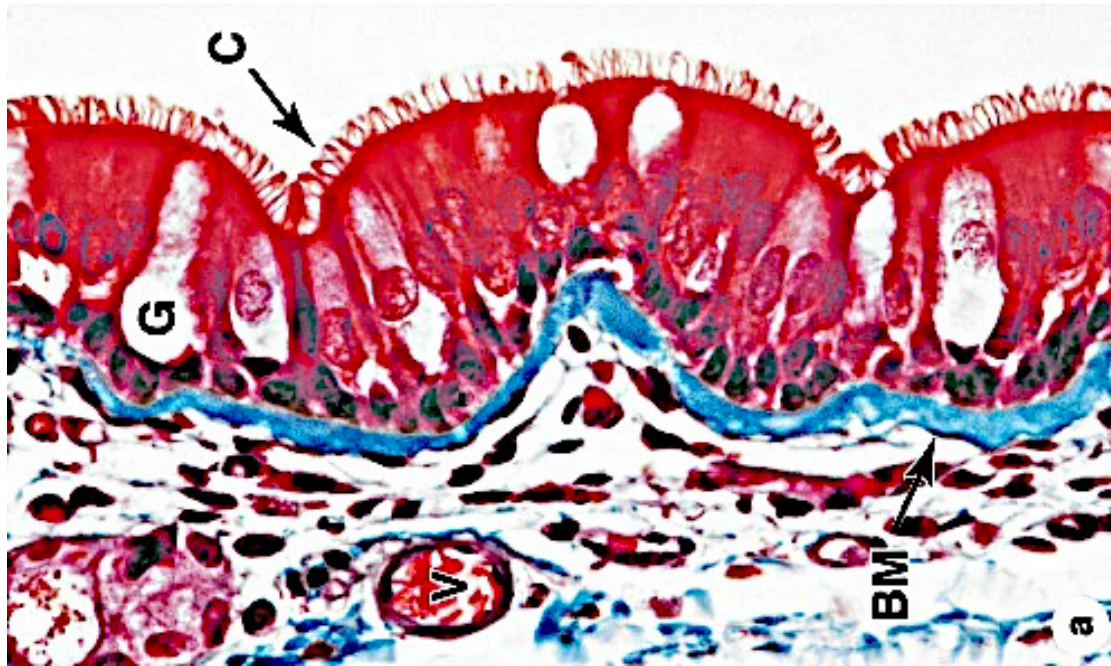
- Ciliated
- Goblet cell
- Brush cells -(chemosensory receptor)
- Small granule cells of Kulchisky
- Basal cells- mitotically active progenitor – gives rise to other epithelial cell types.



Source: Anthony L. Mescher; Junqueira's B
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Trachea and Primary Bronchus

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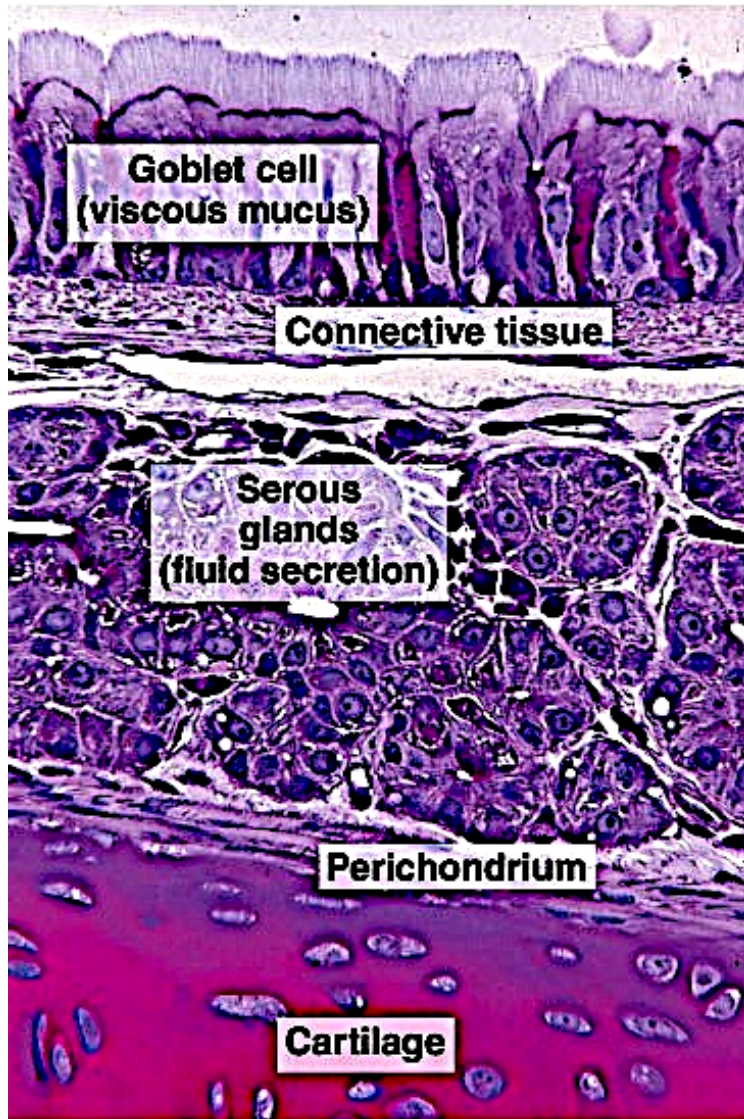


Source: Mescher AL: *Jungueira's Basic Histology: Text and Atlas, 12th Edition*: <http://www.accessmedicine.com>
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Pseudostratified Columnar Ciliated with Goblet Cell

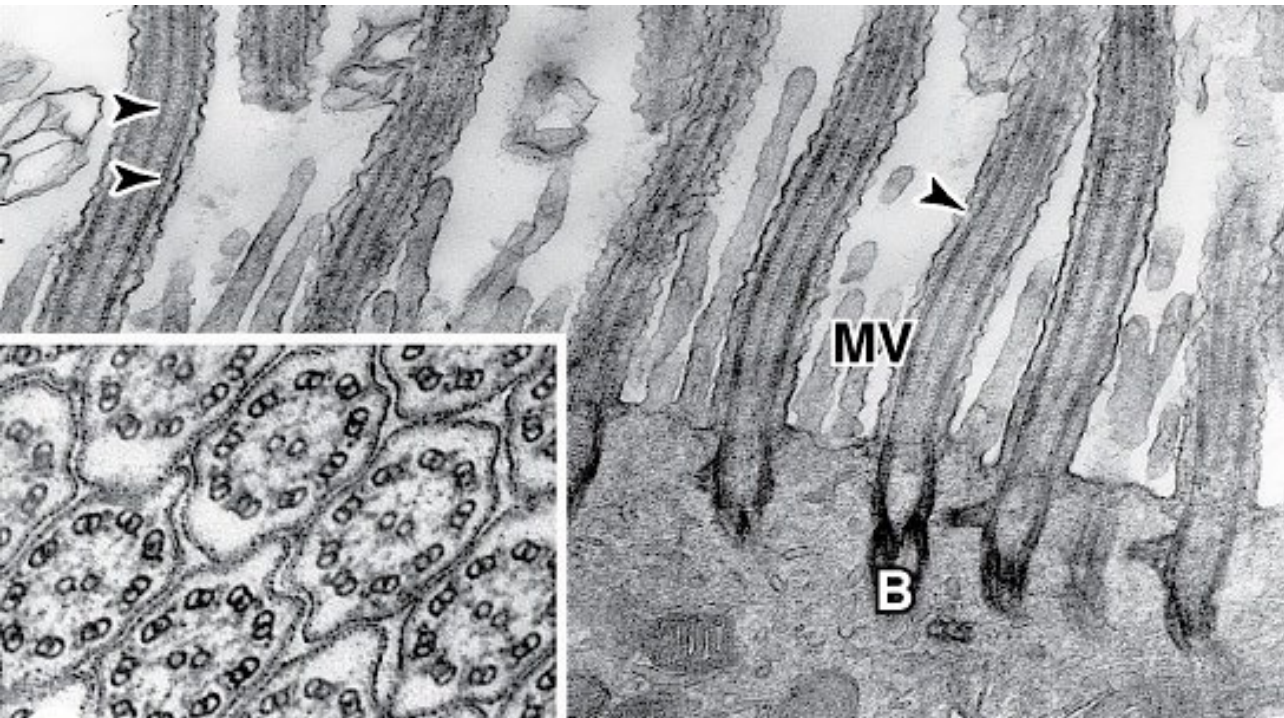
- Thick basement membrane (**BM**)
- Round cells at basement membrane are stem cells
- Goblet cell (**G**) - mucus traps airborne particles
- Intraepithelial lymphocytes
- Cilia (**C**)
- Well vascularized (**V**) lamina propria

Trachea - Submucosa



- Smooth muscle
- Seromucous glands
 - (serous dominance)
- Collagen
- Elastic fibers
- MALT (Mucosa Associated Lymphoid nodules)**
- **Aggregates occur more proximal portion of bronchial tree

Trachea - Cilia



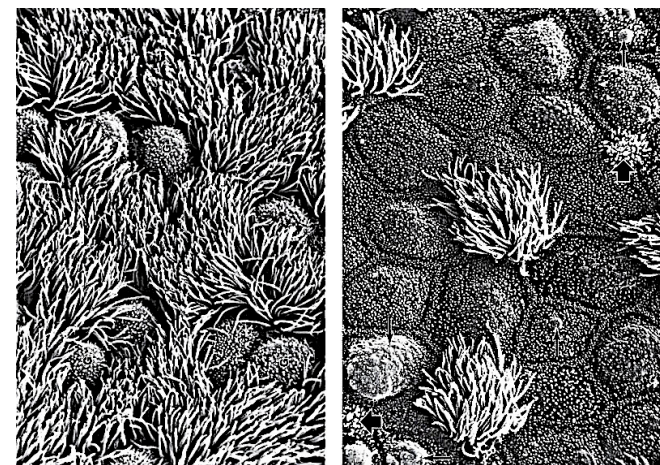
Central pair of microtubules
Surrounded
9 peripheral microtubular
pair that are inserted into
basal bodies.

FUNCTION.

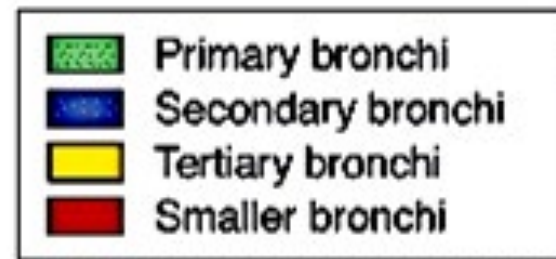
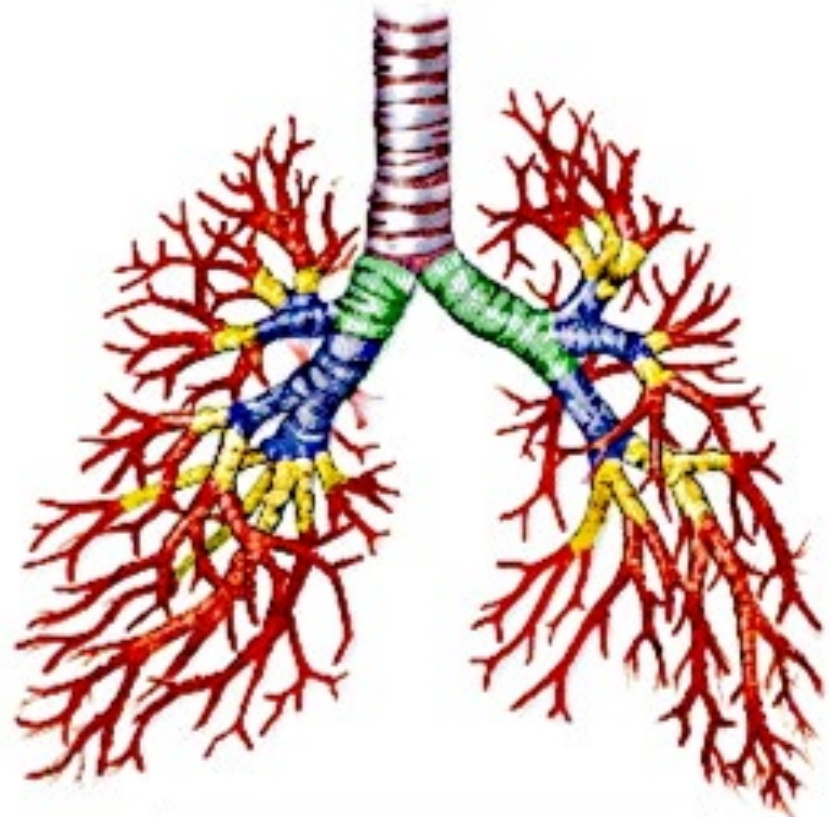
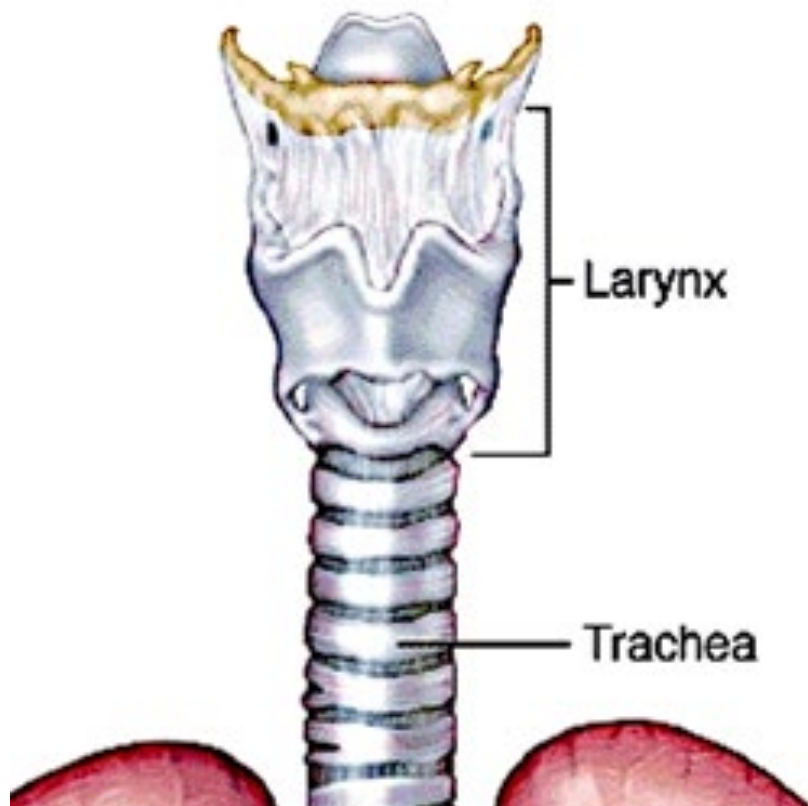
- Rapid back-and-forth movements
- Coordinated
- Propel fluid and suspended matter in one direction.

Movement

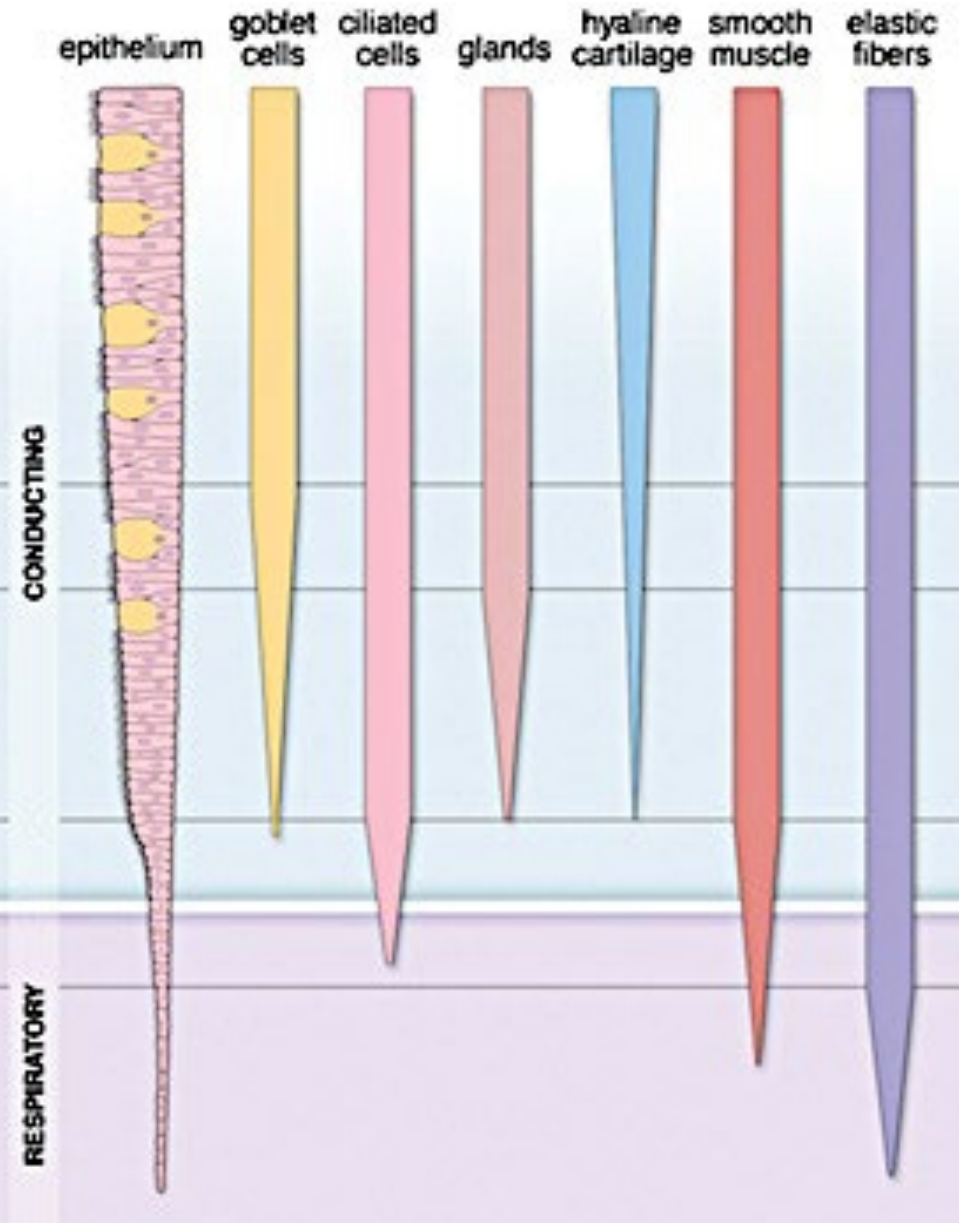
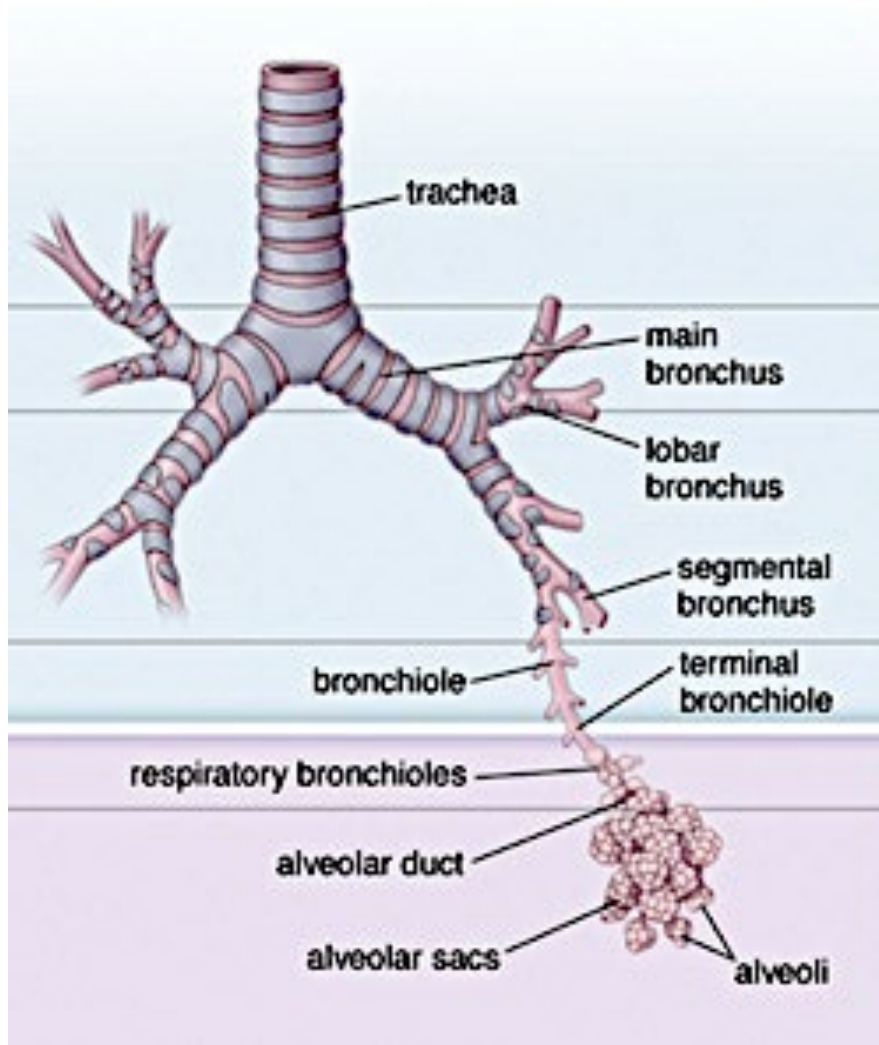
Activity of **ciliary dynein**
present on the peripheral
microtubular doublets
to have about 250 cilia.



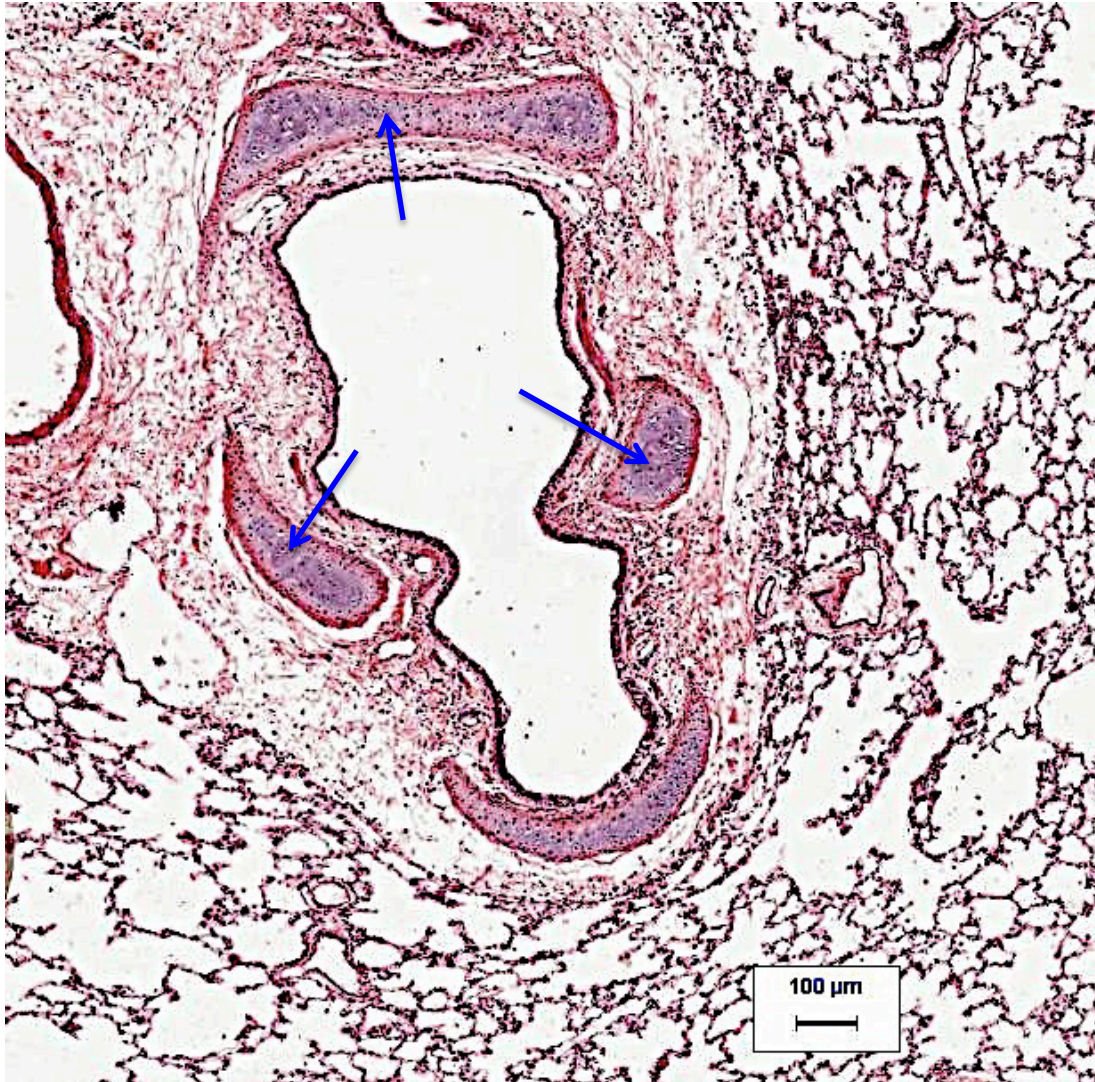
Trachea and Bronchial Tree Anatomy



Tracheo- Bronchial-Bronchiolar Tree



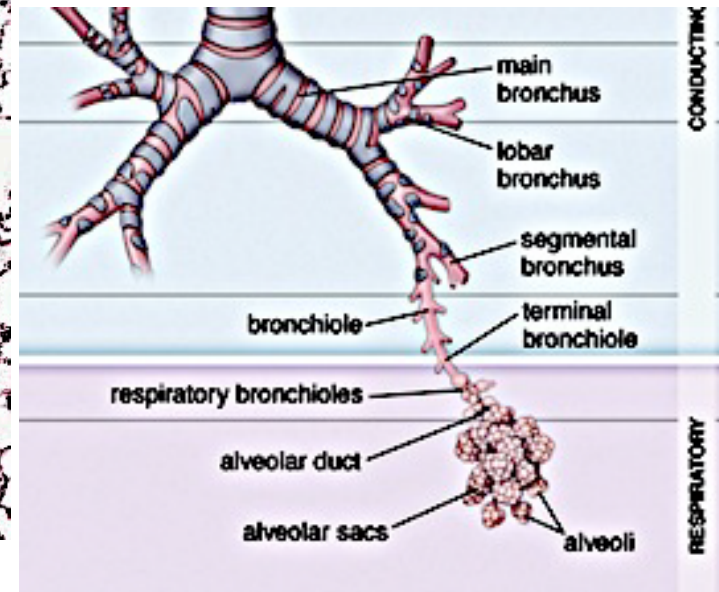
Secondary Bronchus -Intrapulmonary



- Irregular cartilaginous plates (Arrows)

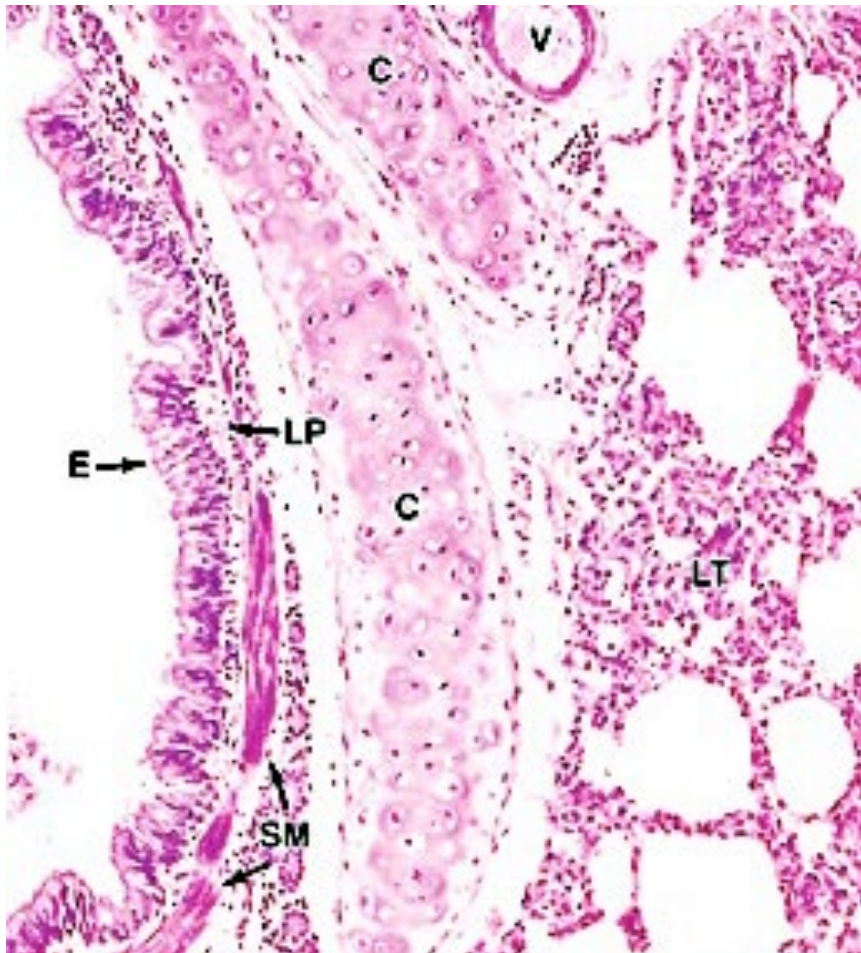
As we go down the bronchial tree

- Cartilaginous plates become more irregular(disorganized)



Bronchial Wall

Large



Small

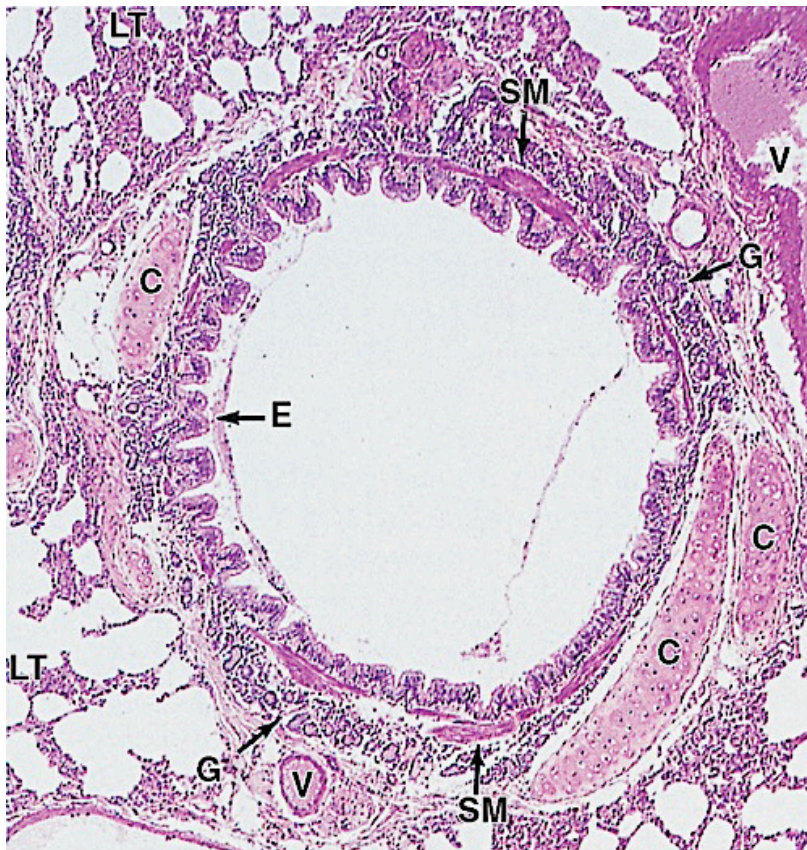


- **E-Epithelium PCC**
- Few Goblet cells
- LP= Lamina propria with distinct muscle layer
- Submucosa part of supportive hyaline cartilage (C)

- **Epithelium- columnar**
- Smooth muscle in lamina propria + small glands (G)

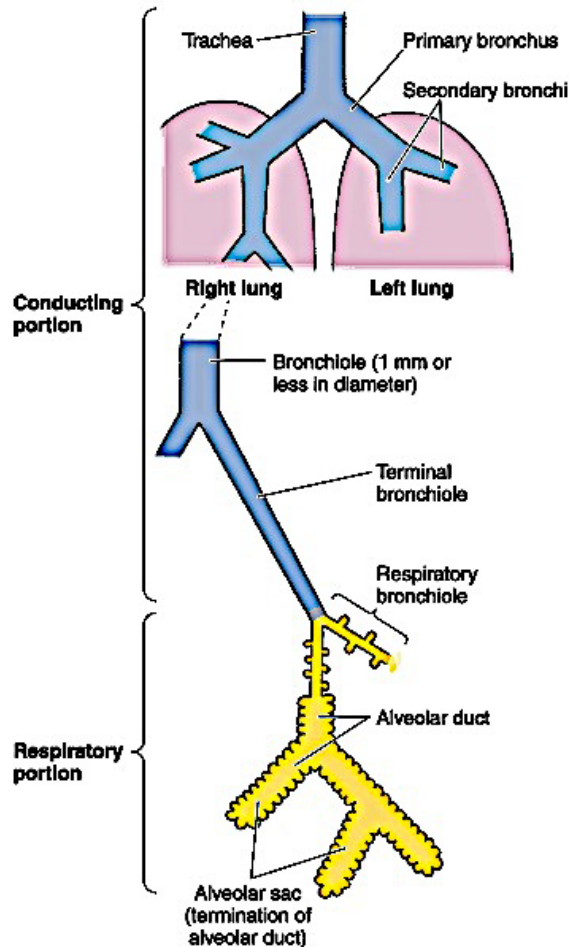
(Primary- Secondary- Tertiary subdivisions)

- Supplies a pulmonary lobe-a bronchopulmonary segment
- Each with its connective tissue capsule and blood supply)



- Seromucous glands (G)
- Folded lining epithelium (E) from contraction of its smooth muscle (SM)
- Surrounded by lung tissue (LT)

From Bronchus to Bronchiole



Continuous subdivisions of bronchi eventually yields the bronchioles

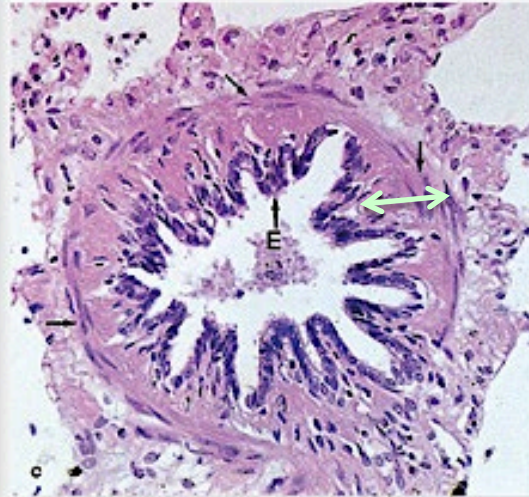
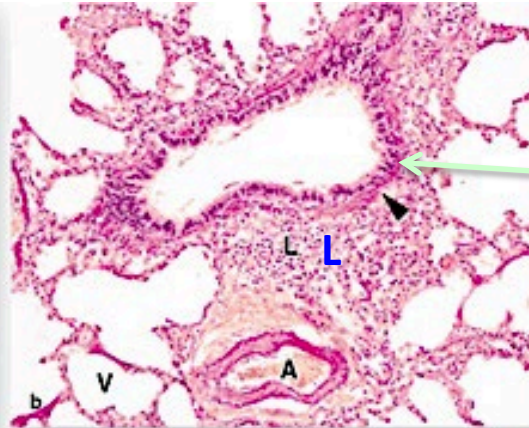
Bronchiole (1mm or less in diameter)

- No Glands
- No cartilaginous plates

Bronchioles (Large - Small)



LARGE BRONCHIOLE



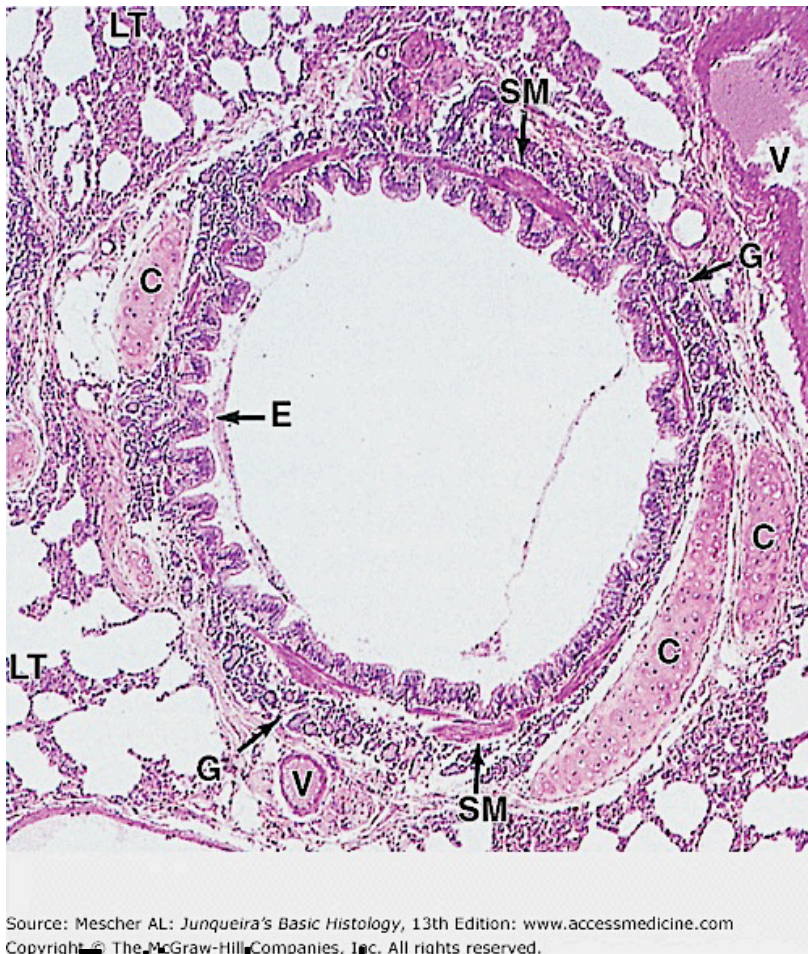
- **L**-Lymphocytes as MALT
- High elastic fibers in Smooth muscle

SMALL BRONCHIOLE

- Epithelium-**Simple cuboidal**
- Several layers of Smooth muscle

- Folded respiratory epithelium
- **Lack cartilage and glands**

Comparing- Bronchus Vs Bronchioles

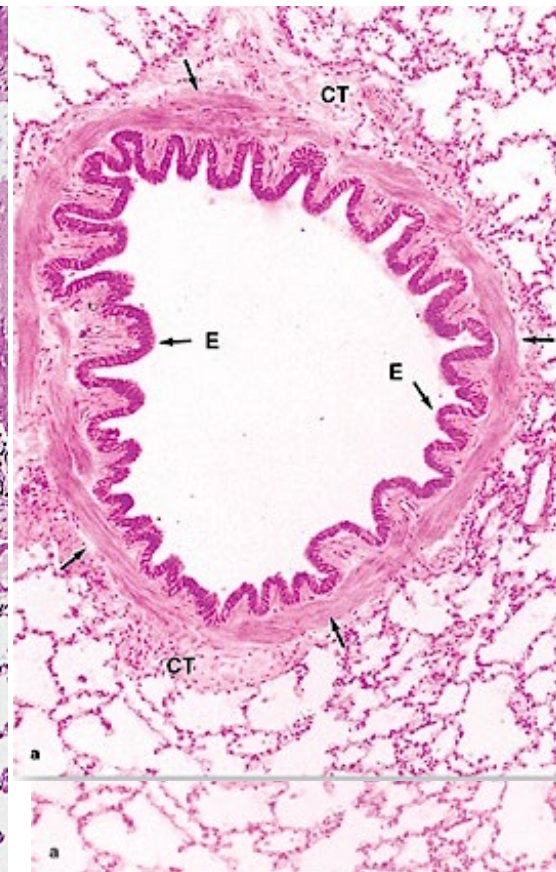


Source: Mescher AL: Junqueira's Basic Histology, 13th Edition: www.accessmedicine.com

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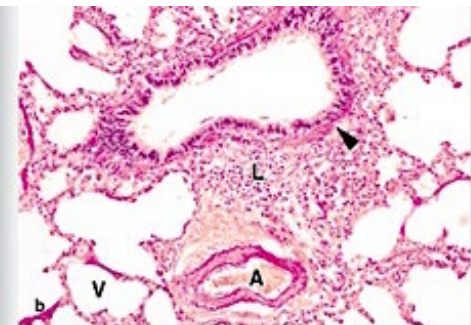
Tertiary bronchus

- **Cartilaginous plates (C)**
- Glands -(G)



Large Bronchiole

- No plates
- **No Glands**

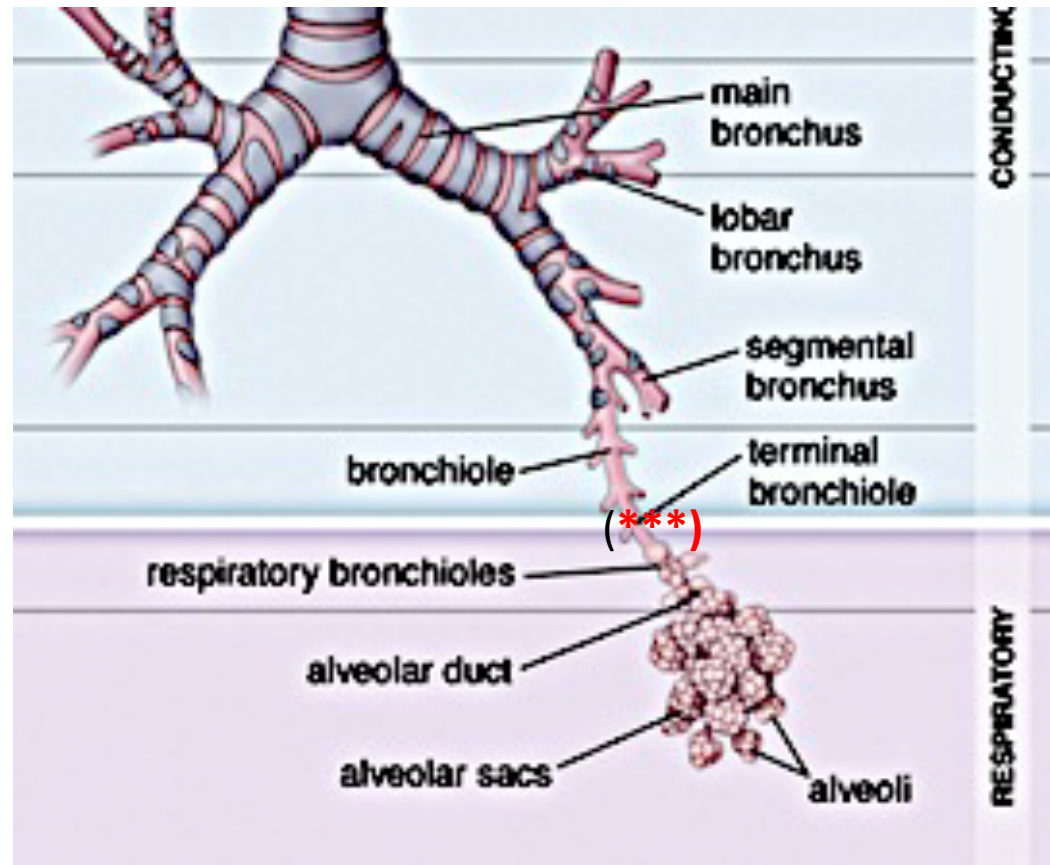
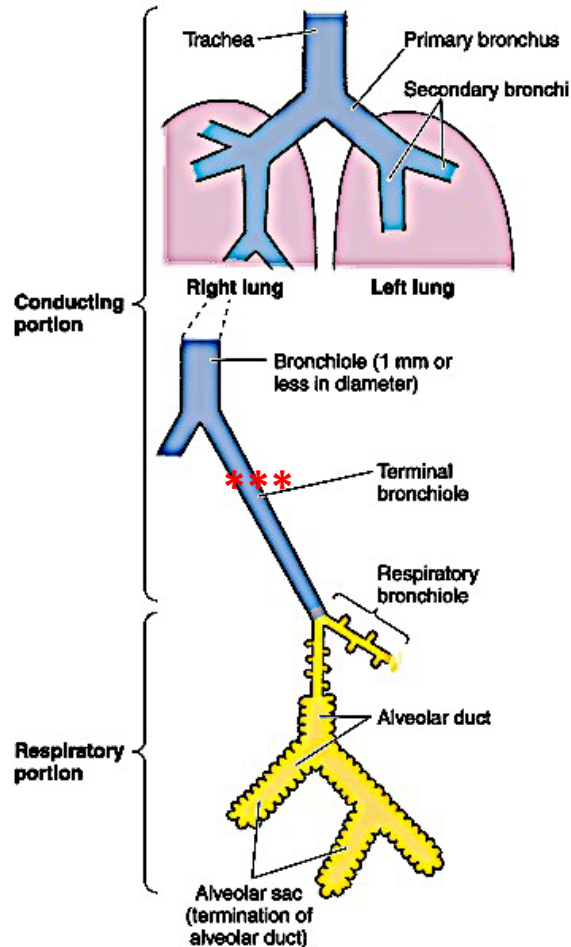


Small Bronchiole

Cuboidal epithelium

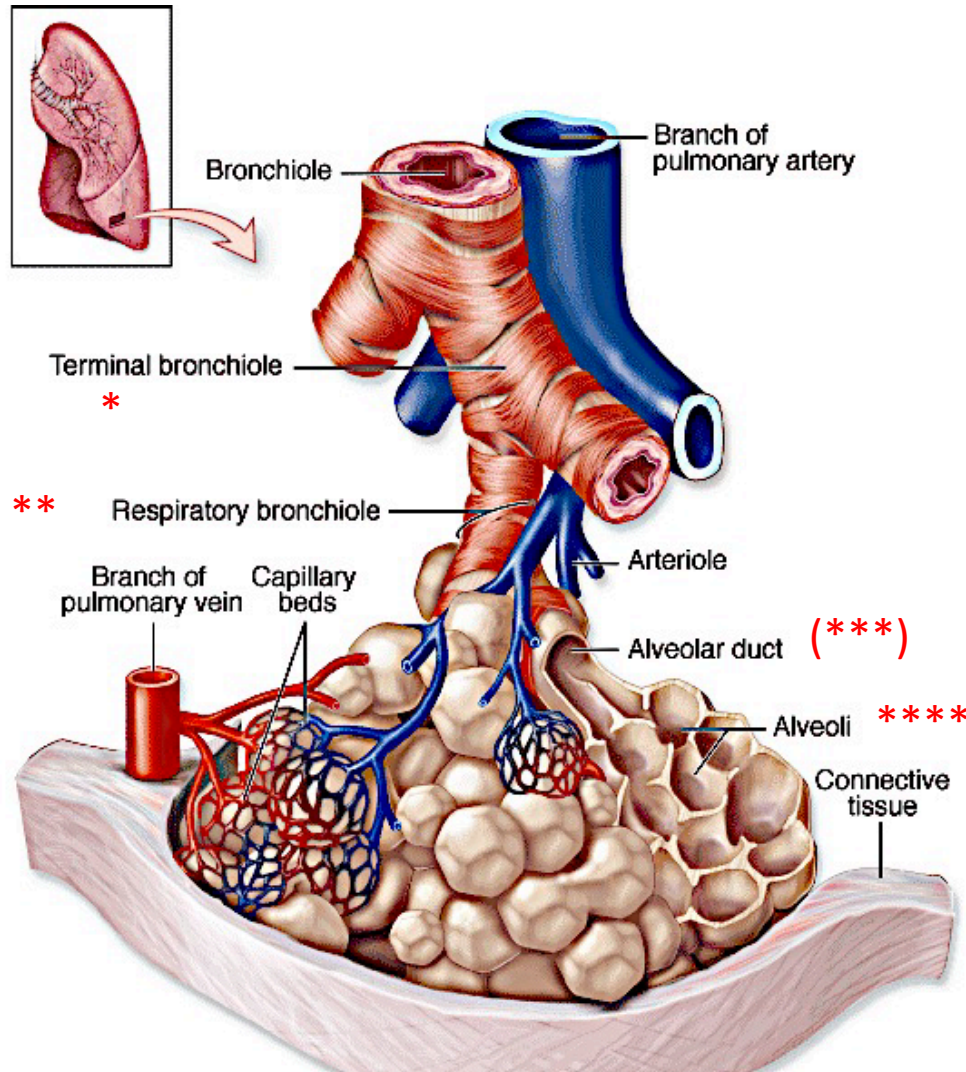
Terminal Bronchiole

- The last parts of the air conducting system before the sites of gas exchange appear are called the terminal bronchioles(***)



From Terminal bronchiole –Alveoli

Branching relationship



Terminal bronchiole (*)



Respiratory bronchiole (**)



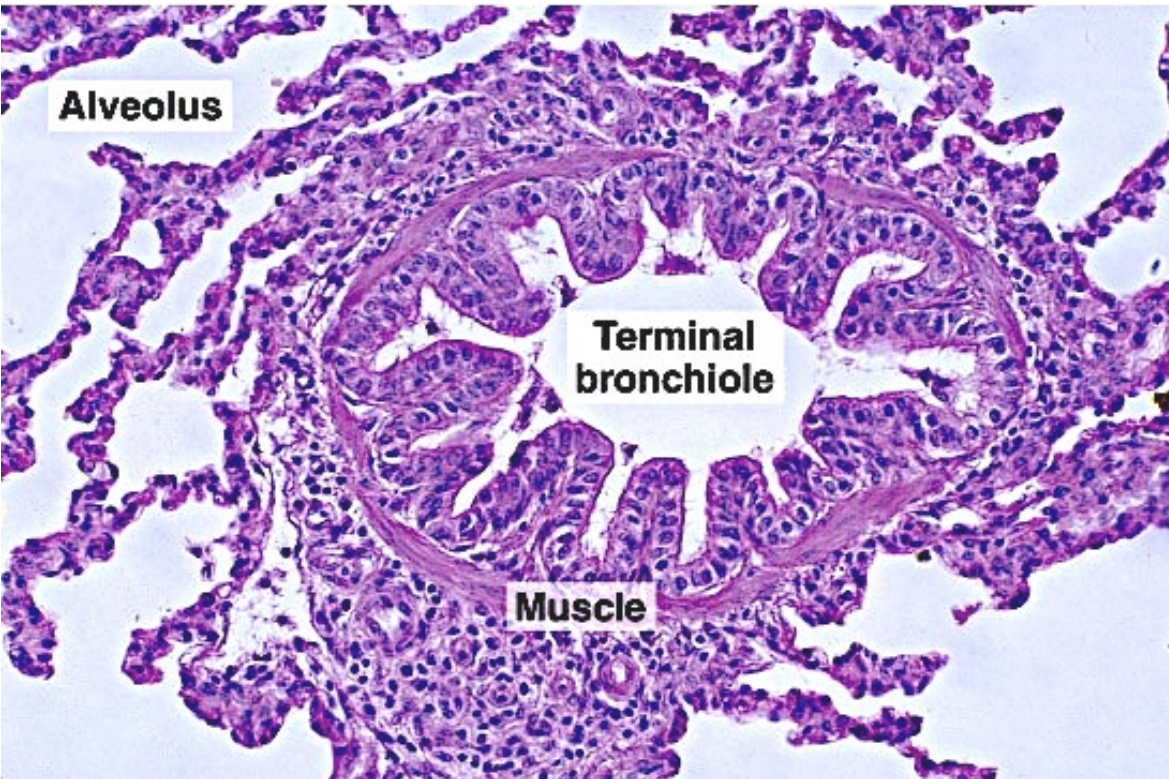
Alveolar duct (***)



Alveoli (****)

Note extensive network of capillaries surrounding each alveolus

Terminal Bronchiole



- No cartilage
- No mucus glands

EPITHELIUM

- Simple columnar transitioning into
 - Simple cuboidal
- ↓
- Distinct muscularis mucosae**

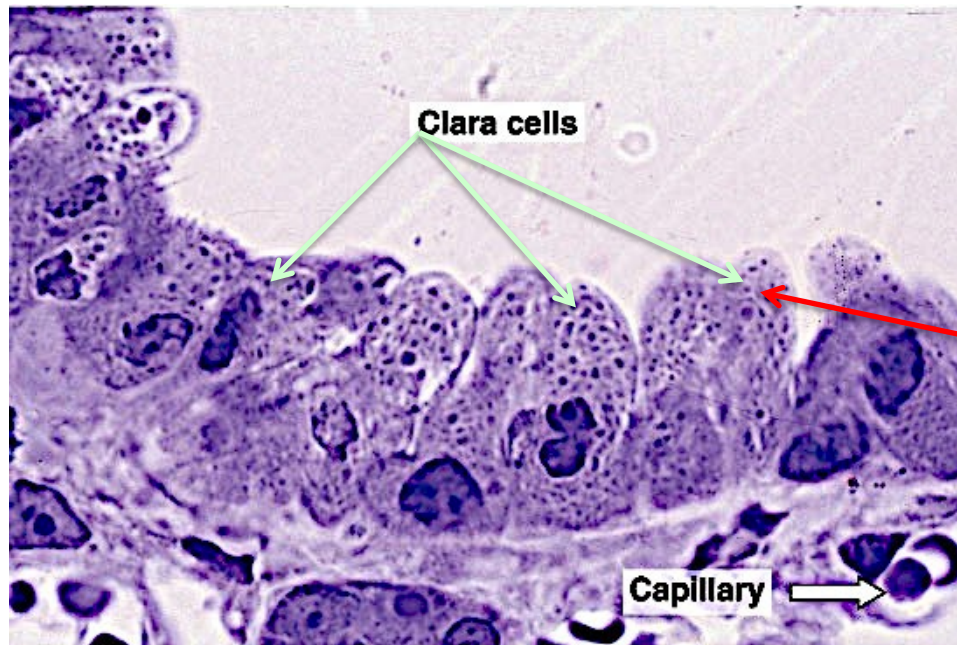


Terminal Bronchiole & Clara Cells

(Exocrine bronchiolar cells)

Epithelium

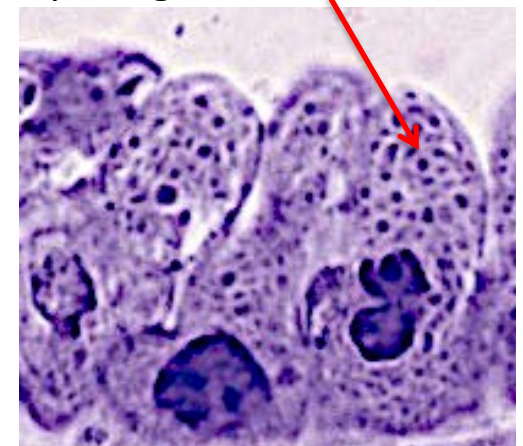
- Mucosa with non-ciliated cuboidal with Club cells (Clara cells)



- Secretes surfactant
- Apical dome-shaped protrusion
- 80% of cell population of terminal bronchiole

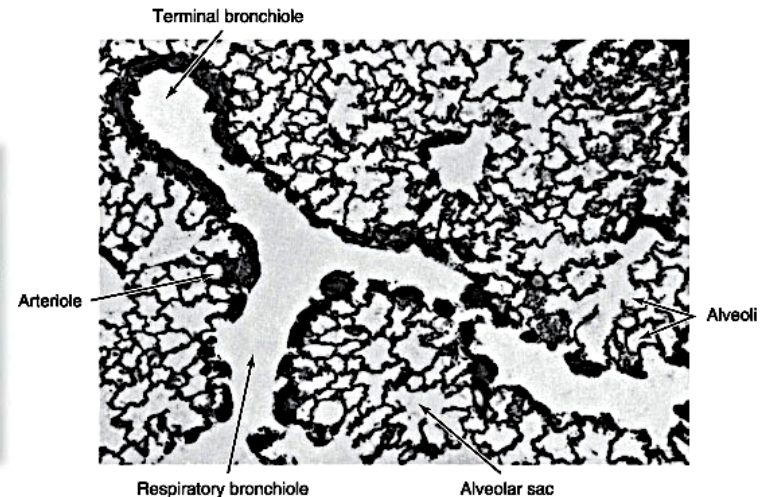
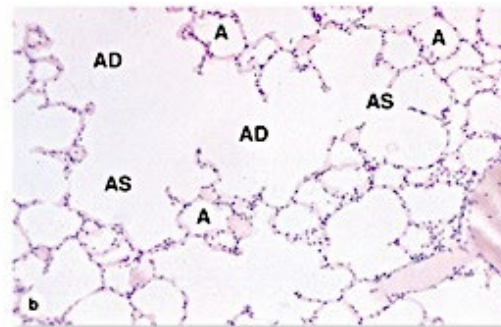
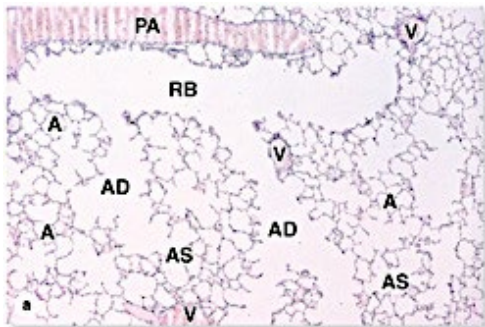
- Detoxification (P450 Enzymes)
- Stem Cells

Exocrine bronchiolar or Club cells with apical granules



Terminal bronchiole vs Respiratory bronchiole

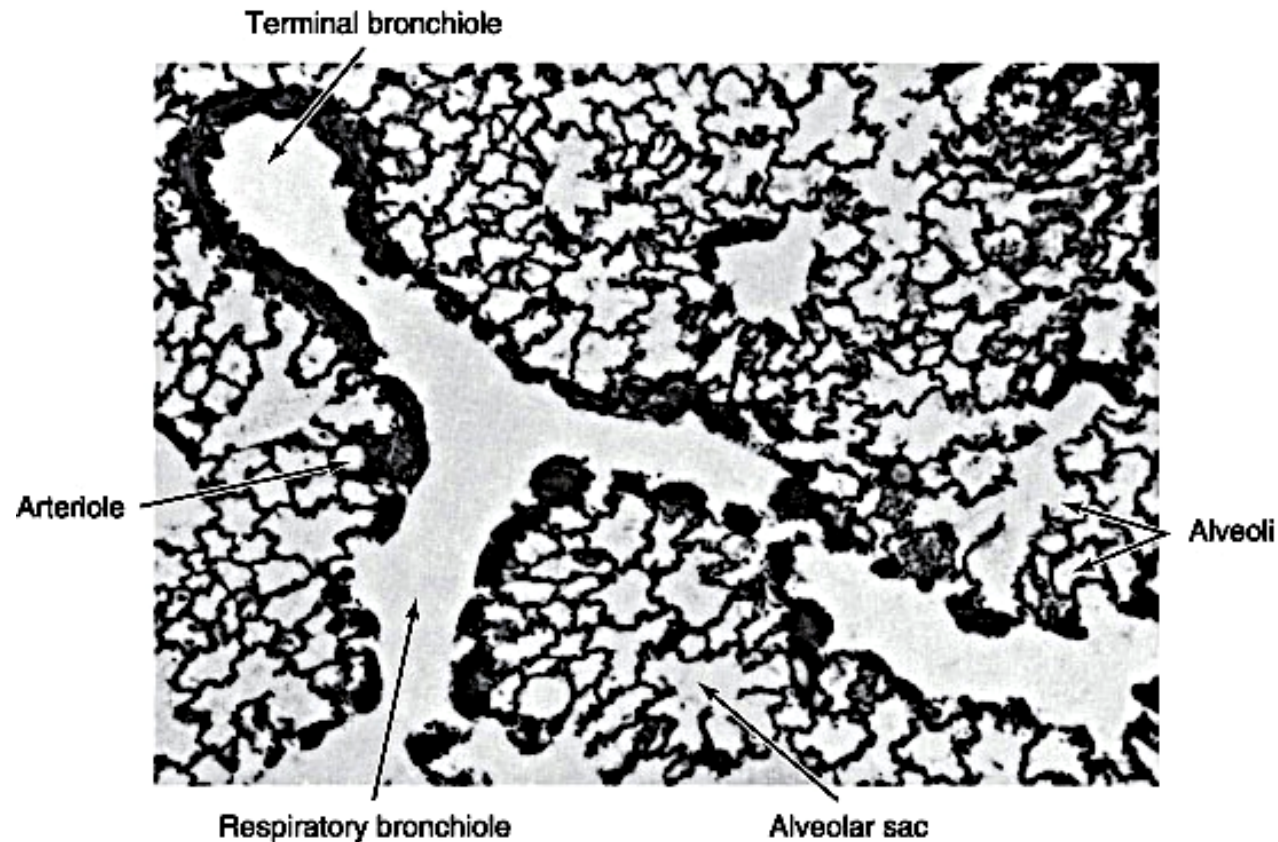
- The respiratory bronchiolar mucosa resembles that of the terminal bronchioles, except for having a **few openings to alveoli** where gas exchange occurs.
- Alveoli -responsible for the spongy structure of the lungs
- About 200 million alveoli



Source: Anthony L. Mescher: Junqueira's Basic Histology, 14th Edition.
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A –alveolus
RS-respiratory bronchiole
AS-alveolar sac
AD-alveolar duct

Terminal bronchiole – Alveoli (2)

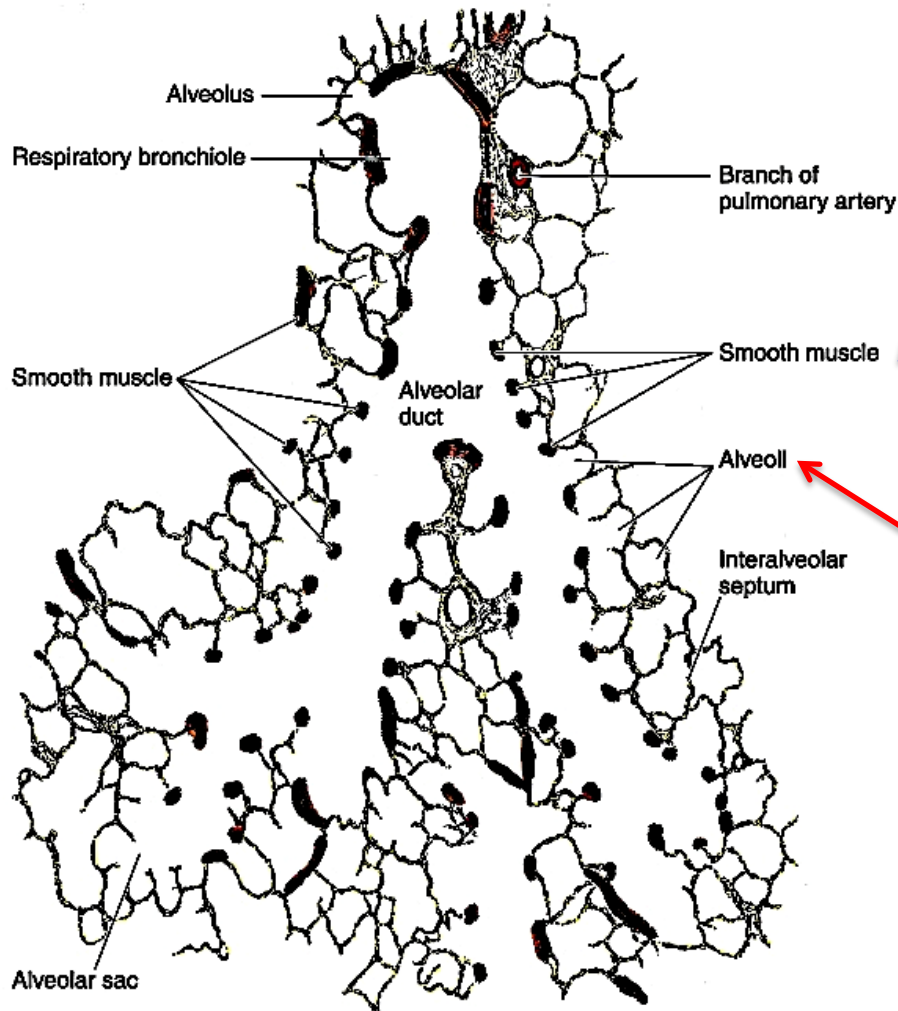


Transition Zone

Wall of the terminal bronchiole - NOT associated with alveoli

Wall of respiratory bronchiole - Associated with alveoli

Alveolar Duct and Alveoli



Alveolar duct

- Distal to respiratory bronchiole

Characteristic

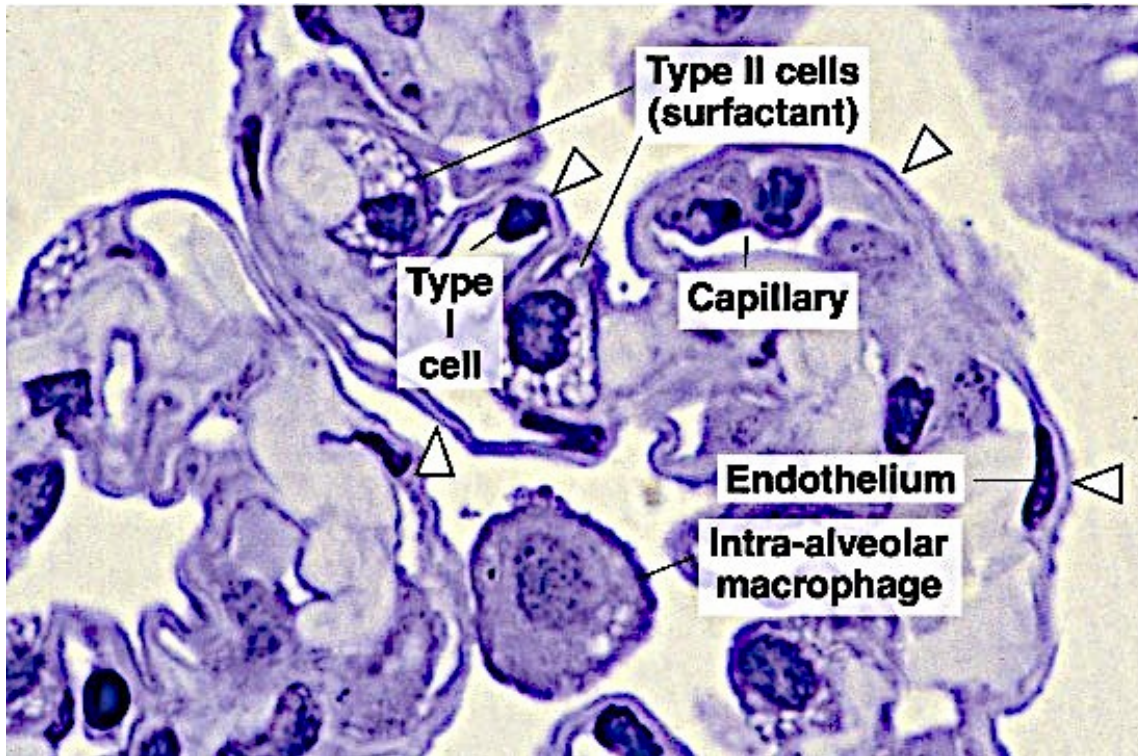
- Smooth muscle knobs bulging into the lumen

Alveoli

- Smooth muscle knobs disappear in the alveoli

Lining with extremely attenuated squamous cells

Pneumocytes (Alveolar epithelial cells)

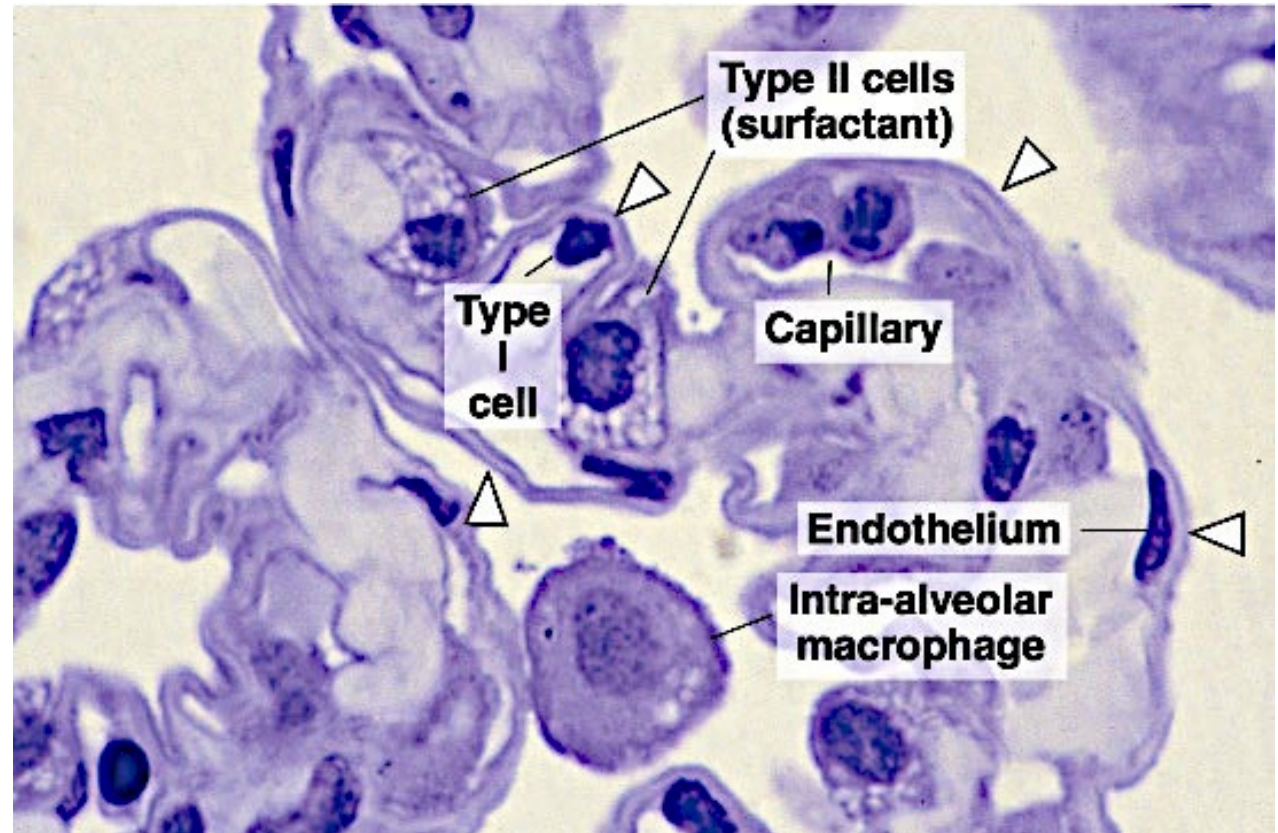
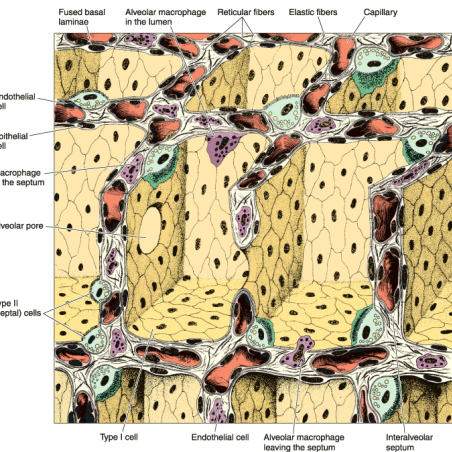


2 cell types

Type I –(Gaseous Exchange

Type II
(Secretes surfactant)

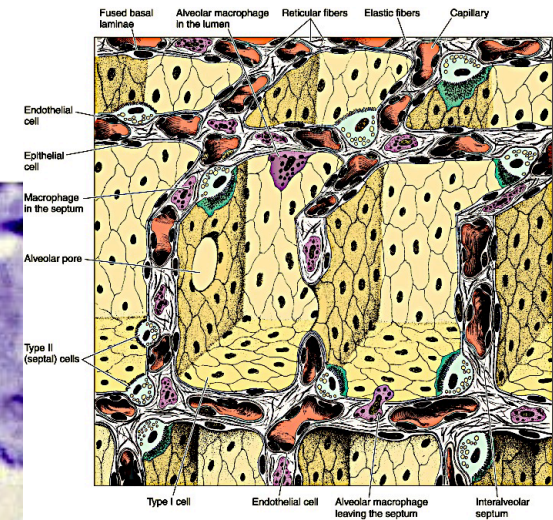
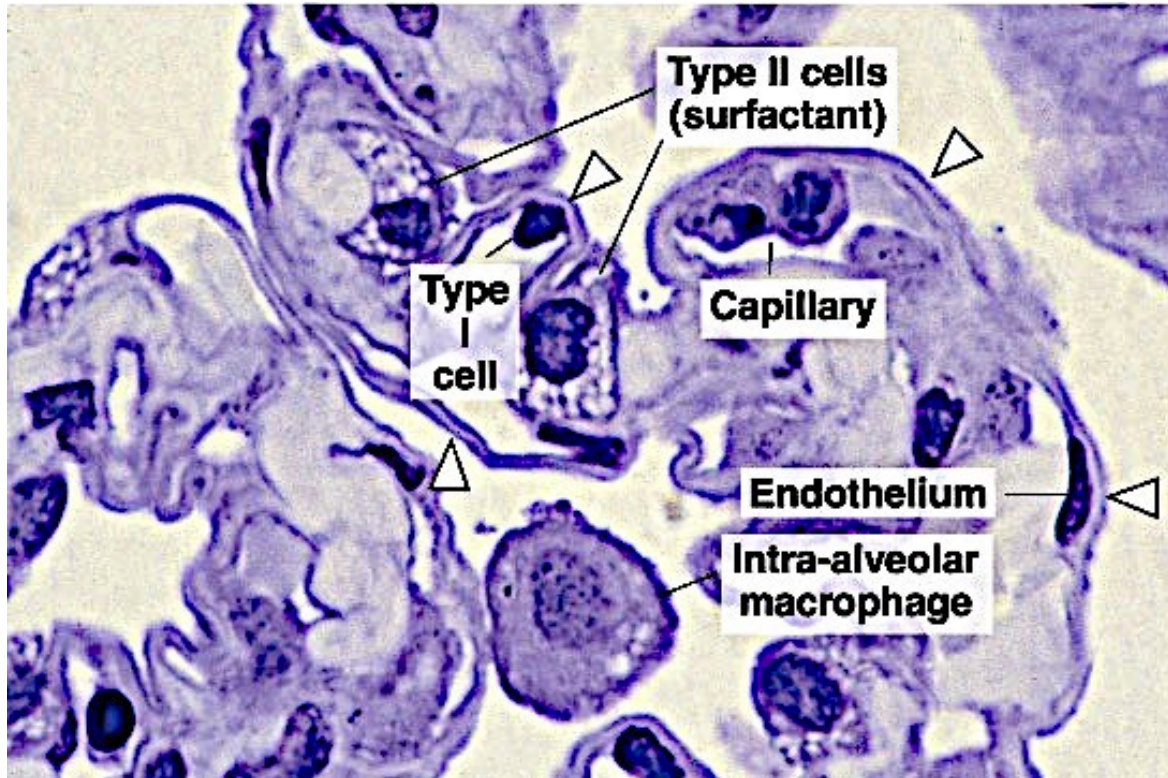
Type I pneumocytes



- 40% of epithelial cell population
- Lines 90% of the alveolar surface

Type II Pneumocytes

Type II or Septal cells



- Granular
 - Roughly cuboidal
 - Surfactant production
 - Can differentiate into Type I
-
- 60% of epithelia cells population.
 - 5- 10% of alveolar surface area
 - Type II cells often occur in groups of two or three at points where two or more alveolar walls unite.

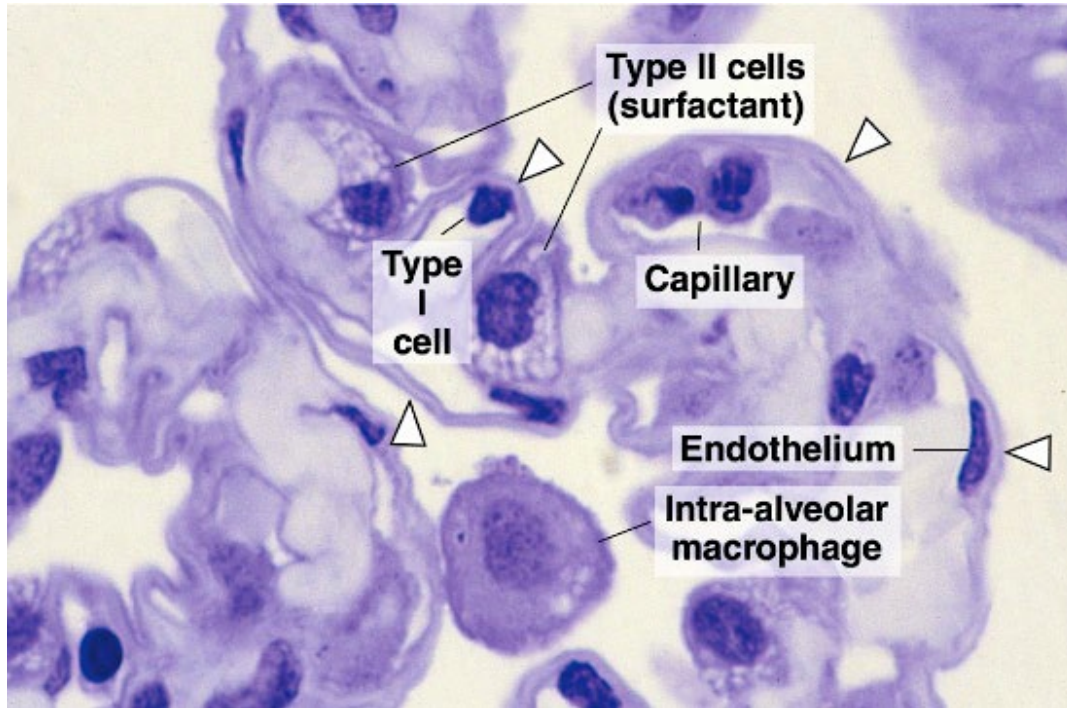
Prematurity and IRDS

In prematurity:

- Deficiency in both the amount and composition of surfactant
- Infant respiratory distress syndrome **(IRDS)** (leading cause of death in premature babies)

Management

- Exogenous surfactant.



- Alveolar macrophages (Big eaters, dust cells)
- Fibroblasts
- Mast cells

Fate of alveolar macrophages

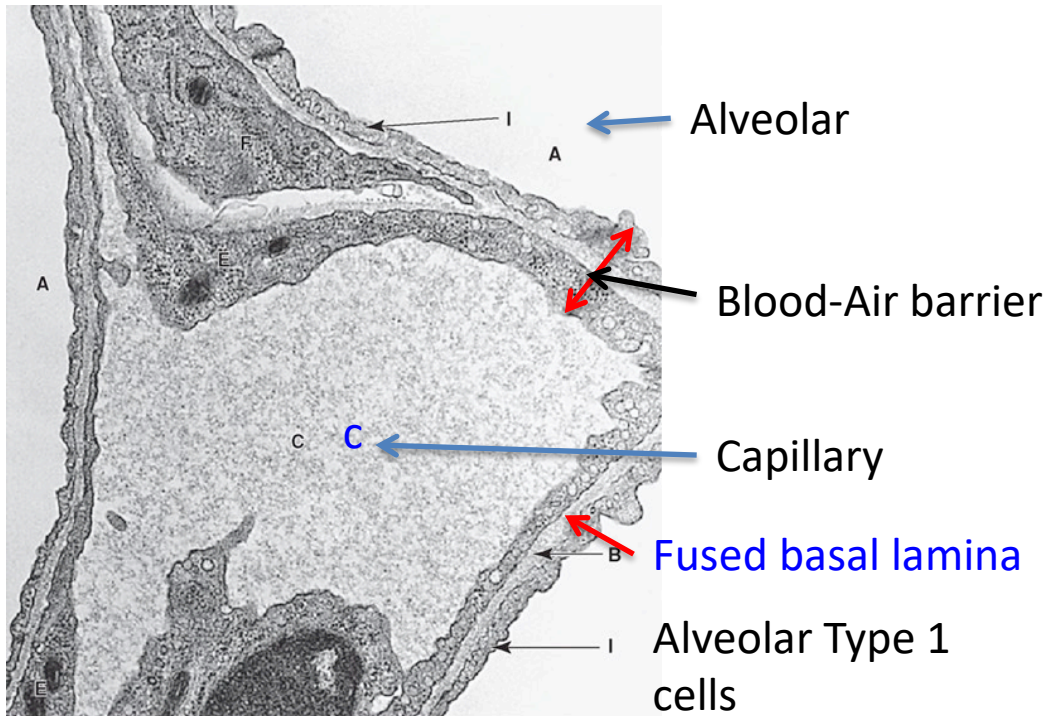
- Migrate into bronchioles
- Mucociliary escalator for removal in pharynx
- Exit lung in lymphatic drainage
- Some remain in interalveolar septal CT.
- Active alveolar macrophages vs type II pneumocytes
Slightly darker
- Dust and carbon from air and complexed iron (hemosiderin) from erythrocytes

Respiratory Membrane or Blood-Air barrier

Air in the alveoli is separated from capillary blood by three components referred to collectively as the **respiratory membrane** or **blood-air barrier**

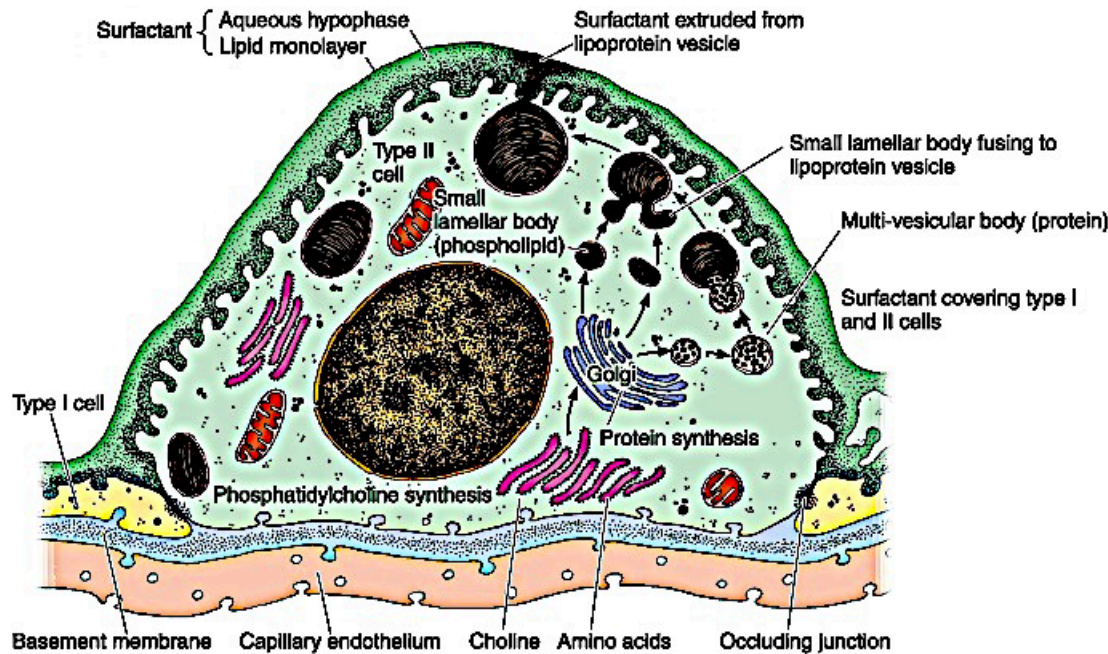
Alveolar walls. TEM

- Two or three highly attenuated, thin cells lining the alveolus
- The fused basal laminae of these cells and the endothelial cells of capillaries, and
- The thin capillary endothelial cells.



Synthesis and secretion of surfactant by a type II cell.

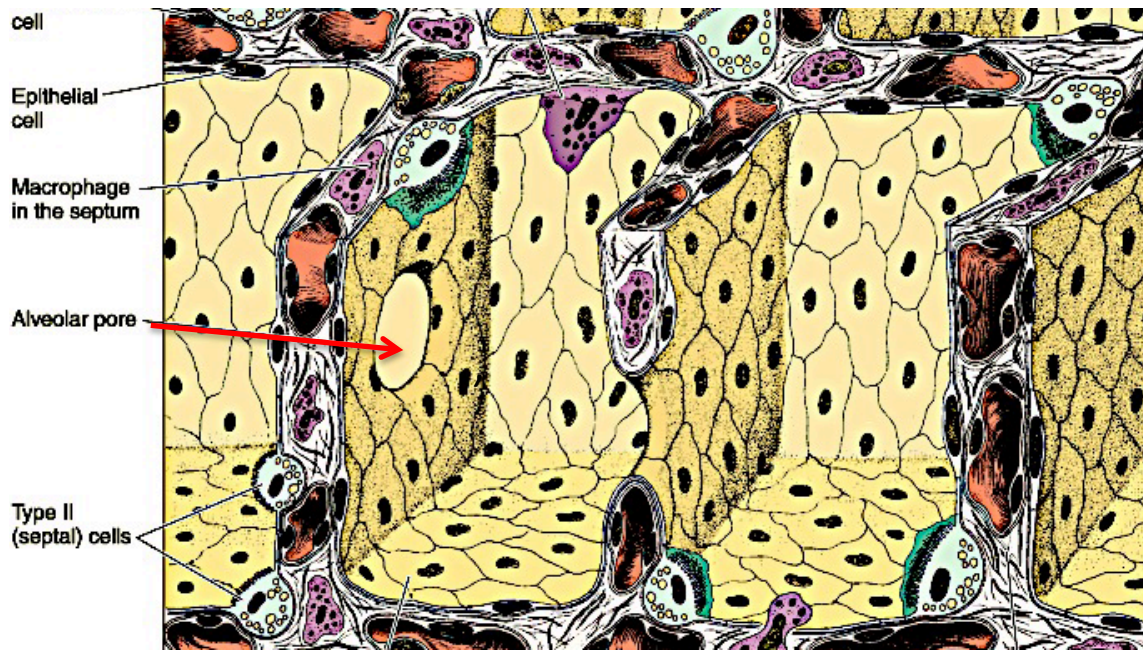
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Surfactant

- Protein-lipid complex (RER-Golgi Complex)
- Secreted continuously by exocytosis
- Lamellar bodies containing newly synthesized pulmonary surfactant**

Schematic Organization of The Lung



- Interalveolar septum
- Capillaries
- Connective tissue
- Capillaries
- Alveolar pores
- Macrophages
- Type I pneumocytes
- Type II pneumocytes

Alveolar pores (of Kohn), ranging 10-15 μ m diameter, penetrate the interalveolar septa and connect neighboring alveoli that open to different bronchioles.

- Pores equalize air pressure in these alveoli
- Permit collateral circulation of air if a bronchiole becomes obstructed.

Clinical Applications 1

Toxins

- Cigarette smoking & Industrial pollution - → Immobilizes Cilia → Failure to clear mucus →
Squamous Metaplasia of epithelium → Precancerous dysplasia

ADENOIDS. Hypertrophied regions of **pharyngeal tonsils** resulting from chronic inflammation .

Anosmia/Hyposmia

Trauma → severance of olfactory axons

Intranasal drug usage & Toxic fumes → Damage to olfactory epithelium

- High regenerative activity of olfactory neurons → Loss of smell (Temporary)

Sinusitis (Inflammatory process) May run chronic from obstruction to drainage openings
(Bronchitis)

Primary cilia dyskinesia

Inherited genetic disorder → Defective ciliary action

Laryngitis

Inflammation plus **edema in lamina propria** Hoarseness/complete voice loss

Croup (Children) Inflammation + edema, With cough and hoarseness **Loud and harsh**

Singers nodules (Benign reactive polyps)

Located . Frequent stratified squamous epithelium on VC -Voice change

Medical application 2.

Cough – productive or dry

- Viral infection irritation of mucosa

Phlegm. Persistent **dry cough**, no mucus produced.

Bronchioles Air passages affected most often, especially in children

Bronchiolitis → Obliterative if chronic

(Measles, adenoviruses)

Lung cancer Affects epithelium lining mostly large bronchi.

Asthma . Bronchospasm affecting smooth muscles in bronchiole

Specific antigens trigger mast cells degranulation

MX-Sympathomimetics

ARDS or Diffuse alveolar damage Injuries to the alveolar epithelial and the capillary endothelial cells.

(Viral → Bacteria → Inhalation of toxic gases → Air with excessive O₂)

Fat embolism syndrome- Adipocytes enters lung during surgery → Circulates → blocks capillary bed

ATELECTASIS

Excess mucus or **aspirated material** → Obstruction of air supply → Collapse of pulm.
Lobules → Circulating blood absorbs gases from affected alveoli
(Mendelson's Syndrome)

Cystic fibrosis (**CF**) Defective protein known as CFTR.

A Defective gene → Causes a thick, buildup of mucus in the lungs, pancreas and other organs.
In the lungs, the **mucus clogs** the airways → Traps bacteria → infections → extensive lung damage , eventually → respiratory failure.

CF - Autosomal recessive → mutations in both copies of the gene for the cystic fibrosis transmembrane conductance regulator (CFTR) protein.

Diagnosis : Very salty-tasting skin
Genetic testing.

PLEURISY- Inflammation of parietal pleura

PNEUMONIA –Inflammation in respiratory regions